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TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 107
OCTOBER, 1920

MUNICIPAL WASTES

THEIR
CHARACTER—COLLECTION—DISPOSAL

BY

H. R. CROHURST
Associate Sanitary Engineer
United States Public Health Service

PREPARED BY DIRECTION OF THE SURGEON GENERAL

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GOVERNMENT PRINTING OFFICE
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MUNICIPAL WASTES: THEIR CHARACTER, COLLECTION, DISPOSAL.

INTRODUCTION.

The collection and disposal of refuse in a sanitary and economical manner is a problem that sooner or later has to be faced by every growing community.

In the rural districts the problem is one of the individual; no collection is necessary. There are usually stock or other animals that can dispose of a portion of the edible refuse, combustible waste can be burned and, where considerable area is available, the disposal of the remaining waste offers no serious problem.

In the suburban community, with its increased density of population, areas near at hand for the proper disposal of wastes are not always available. The problem is still one of the individual, but as he does not always have the necessary means of transporting the waste to the point of final disposal, the community scavenger springs into existence, who collects and disposes of the wastes in such a manner that returns him the greatest revenue. Collections of this character are not always regular or satisfactory, as naturally those places from which the greatest revenue can be obtained will receive the more efficient service, while the refuse from the producers which has little or no value will be collected irregularly or not at all. Disposal by the community scavenger is not always in accord with the most modern or sanitary methods and the points of disposal may become a source of great annoyance to those living in the neighborhood.

As the community passes from the suburban to the urban, with its business district, stores, office buildings, hotels, and markets, the disposal of refuse can not be left to the individual. The problem is one that affects the general welfare and health of the community as a whole and as such should be assumed by the officials of the municipality and the efficient collection and proper disposal should be worked out to a satisfactory conclusion by them.

The first part of the problem, that of collection, offers no serious difficulties, but requires a careful study and adjustment of details, which will vary in different localities.

The best method of disposing of the wastes after collection offers a greater difficulty of solution and the problem is very closely related to the health and comfort of the community. Sanitary methods of disposal are well understood. The method to be selected for any particular municipality depends upon many local conditions. Separation governs disposal methods to a large extent, or rather upon the method finally selected for the ultimate disposal will depend what separations are to be made.

If all refuse is collected mixed, disposal is limited to dumping into water, if a large volume is available, or on land as a fill. In some places mixed refuse is incinerated, but it seems to be the consensus of opinion that it is not economical to pass the ashes through the incinerator, which makes necessary the carting of the ashes to the plant and then away again when ashes might just as well be carted directly to the point of final disposal in the first place.

If garbage is separated from the ashes and rubbish, reduction is available as a means of garbage disposal in cities over 100,000 population (in cities smaller than this the amount produced is not sufficient to make the process feasible), or garbage may be fed to animals. Both of these methods, under proper supervision, should yield some revenue from the process. Garbage may be disposed of by burial, from which no return other than enrichment of the land is obtainable. The remaining two combined wastes, ashes and rubbish, then must be disposed of, usually by filling low areas.

Where ashes are separated from garbage and rubbish, incineration is usually the method adopted for the combined wastes and the ashes are used for fills.

Where the wastes are all separated, garbage can be reduced (in the larger cities), may be utilized by feeding to hogs, or can be disposed of by burial. Ashes are removed for fills and the rubbish may likewise be disposed of in fills or may be sorted for salable material and the remainder burned.

The solution of the problem of separation, collection, and disposal of refuse for any given locality can not be solved by any fixed rule. The object to be obtained is an efficient method of collection and disposal, in a sanitary manner and at a reasonable cost, of all classes of wastes.

No method of utilizing municipal refuse has as yet been developed that will cover both the cost of collection and disposal. Reduction and feeding may, in favorable circumstances, yield sufficient revenue to pay for the process of disposal and in some cases may help pay the cost of collection, but in every instance collection and disposal will represent an expenditure of funds, on the part of the municipality, that must be provided for in the budget of expenses.

The waste material of a community consists of animal, vegetable, and mineral matter which has been discarded by the individual, as having no further value to himself. This waste may undergo decomposition and cause very objectionable odors, if not an actual nuisance, at the point of storage.

Municipal waste may be divided into sewage, garbage, rubbish, ashes, street sweepings, stable manure, excreta, and dead animals. In the discussion of the municipal wastes, sewage will be omitted. The disposal of sewage in a satisfactory, safe, and sanitary manner has now been placed upon such a sound basis and the various methods or combination of methods so well demonstrated in practice, that no discussion is necessary in this article.

The remaining municipal wastes may be divided into those that are a direct result of the activities of the population of the community (garbage, ashes, rubbish, and excreta), those produced by or as a result of animals kept for pleasure, convenience, or food material, by members of the community (manure and dead animals), and the wastes resulting from the combination of the above (street sweepings or catch basin cleanings).

The amount and composition of the various classes of wastes are dependent upon the character of the population contributing them. In the higher class residential districts the amount of garbage, per person, will be much higher and contain more of the original food substances than wastes from the poorer residential section and much more than from the foreign section, if the community has one. The geographical and climatic location influences, to a considerable extent, the amount of waste per inhabitant. In the northern communities, with their longer winters, more ashes are produced; also the necessity for higher food values, such as fats and carbohydrates, in winter, shows a marked effect on the production and richness of the garbage. The amount and character of the waste, especially garbage, shows a marked variation with seasonal changes from the winter meat diet to the summer vegetable diet

CHARACTER OF MUNICIPAL WASTES.

GARBAGE.

Garbage consists of the waste material from household, hotel, or restaurant kitchens and the vegetable and animal wastes from markets, grocery stores, and similar establishments. Included in its composition are compounds that undergo putrefaction almost immediately, and unless the garbage is removed regularly and frequently conditions of a distinctly insanitary nature will develop at the point of storage. Because of its composition, garbage is one of the most important of the municipal wastes and its removal and proper disposition present the greatest difficulty.

Garbage varies in its composition with the sectional location of the community producing it, with the season of the year and even with the different districts in the same community. The character of the population has a marked effect, both on the quality and quantity of the garbage produced. The greatest production of this class of waste occurs in the summer months and early fall, the minimum in the winter months. At Savannah, Ga., records kept at the incinerator plant indicate that during July and August, the melon season, there is a daily increase in the amount of garbage of nearly 20 tons, which is practically all watermelon rinds and cantaloup skins. Other cities, especially those in the South, report similar increases.

The weight of garbage depends upon the material entering into its composition and upon the amount of water, in a free state, that is held in the voids of the mass. The amount of this free water depends upon the amount of draining that the garbage gets before the householder places it in the receptacle, the kind of receptacle it is stored in, whether water-tight or not, covered or open, and the weather conditions previous to the time collections are made. As a result of these conditions the weight of garbage per cubic yard may vary between 1,000 and 1,500 pounds.

In Table No. 1 there are shown data relative to the physical and chemical characteristics of garbage, compiled by and published in the special garbage report of the Ohio State Board of Health, 1910.

TABLE NO. 1.—*Chemical and physical characteristics of garbage.*

	Cincinnati.[1]	Cleveland.[2]	Columbus.[3]	Dayton.[4]
Per cent of moisture	76.6	75.6	76.4	80.6
Per cent of dry matter:				
Ash	15.65	13.12	13.98	13.19
Phosphoric acid (P_2O_5	1.26	.99	.95	1.00
Kjeldahl nitrogen	2.74	2.61	2.50	2.65
Potash (K_2O)	1.18	1.23	1.08	1.03
Ether extract	17.15	15.85	16.74	19.77
Combustible matter	84.35	86.88	86.02	86.81
Calorific value, B. T. U	8,558.00	8,459.00	8,448.00	8,776.00
Weight per cubic yard	1,227.00	1,333.00	1,173.00	1,475.00

[1] Average of 10 regular monthly samples taken during September, 1909, to June, 1910. Weights—wagon weights at loading station, average of week of sampling.

[2] Average of 20 regular samples taken during May, 1909, to June, 1910, and 14 additional samples taken during June and December, 1909. Weights are railroad car weights on sampling day.

[3] Average of 31 regular samples taken during May, 1909, to June, 1910, and 19 additional samples taken during November and December, 1909. Weights—wagon weights en route on sampling day.

[4] Average of 30 regular samples taken during May, 1909, to June, 1910, and 18 additional samples taken during July, 1909, and January, 1910. Weights—wagon weights at loading station on sampling day.

A study of the available municipal records shows a very wide variation in the average yearly per capita production of garbage. This is due in part to the climatic location of the community and the diet of the population, differences in the type of community, whether, industrial, manufacturing, residential, or one with many hotels supporting a floating population. Some variation is accounted for by the garbage not included, where collections are made by private collectors and some to the failure of the municipality to keep accurate records of the amounts collected. The figure commonly used in the past as the average annual amount to be expected per person has been 200 pounds. Records for the past two or three years show that there has been a considerable reduction in the total and per capita production of garbage, due to the higher cost of food materials and conservation on the part of the population as a whole.

In Table No. 2 there is shown the total yearly tonnage and the yearly per capita production of garbage for several years in the same and in different cities.

TABLE NO. 2.—*Annual production of garbage, total and per capita production.*

City.	Population.	Year.	Annual production.	
			Tons.	Pounds per capita.
Boston, Mass	781,600	1917	60,744	156
	762,300	1916	70,075	184
Buffalo, N. Y	473,200	1918	17,056	72
	475,800	1917	21,627	91
	478,300	1916	31,459	131
Columbus, Ohio	225,400	1918	15,630	139
	220,000	1917	17,127	156
	....	1916	....	203
	....	1915	....	218
Indianapolis, Ind	290,400	1918	20,892	144
Milwaukee, Wis	453,500	1918	31,321	138
	445,000	1917	30,975	139
Philadelphia, Pa	1,761,500	1918	104,500	118
Rochester, N. Y	264,900	1918	29,271	221
	264,700	1917	25,971	196
St. Louis, Mo	768,600	1917	38,493	100
	757,300	1916	45,136	119
	746,000	1915	49,745	133
St. Paul, Minn	257,700	1918	15,108	117
	252,500	1917	14,174	112
	247,200	1916	19,215	155
Washington, D. C	401,700	1918	53,258	265
	369,300	1917	48,874	265
	364,000	1916	44,683	245

Population as of July 1 for year indicated, United States census estimates.

With the exception of Rochester, N. Y., and Washington, D. C., Table No. 2 shows the annual per capita production to be considerably below 200 pounds. The Washington figures are undoubtedly high, as the census estimate does not represent the increase in population brought about as a result of the war activities. The average of all figures for the year 1918 show the annual per capita production of garbage to be about 150 pounds.

To show the effect of decreased food supply, combined with higher prices and the resulting conservation during the war period, there is presented in Diagram No. 1 data on total garbage production for the city of St. Paul, Minn. The data are grouped by seasons for each of the years 1915 to 1918, inclusive, and shows the decreased production during the years 1917 and 1918, also the seasonal variation during each of the years, with the maximum production in the warmer months.

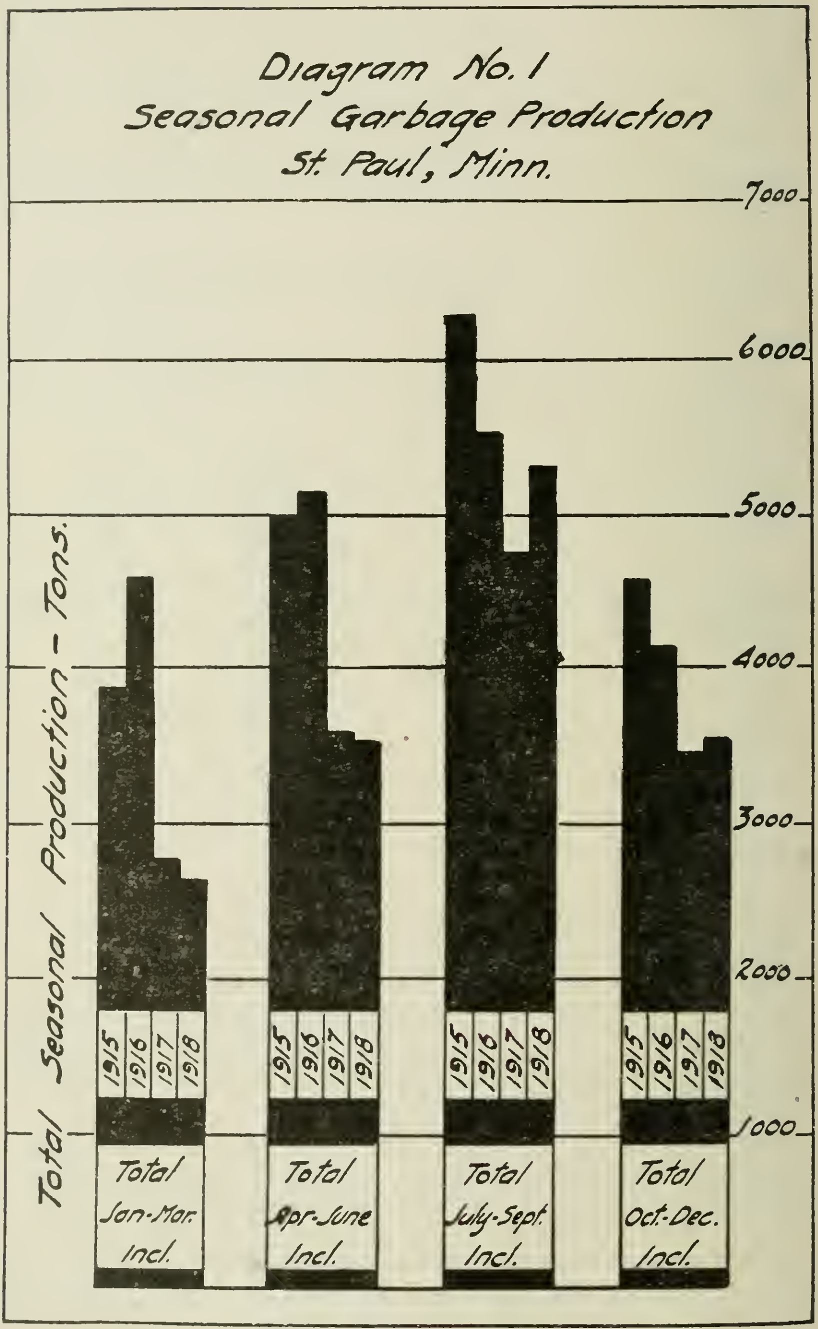
Diagram No. 1
Seasonal Garbage Production
St. Paul, Minn.
7000
6000
5000
4000
3000
2000
1000
Total Seasonal Production - Tons.
1915
1916
1917
1918
Total Jan-Mar. Incl.
Total Apr-June Incl.
Total July-Sept. Incl.
Total Oct.-Dec. Incl.

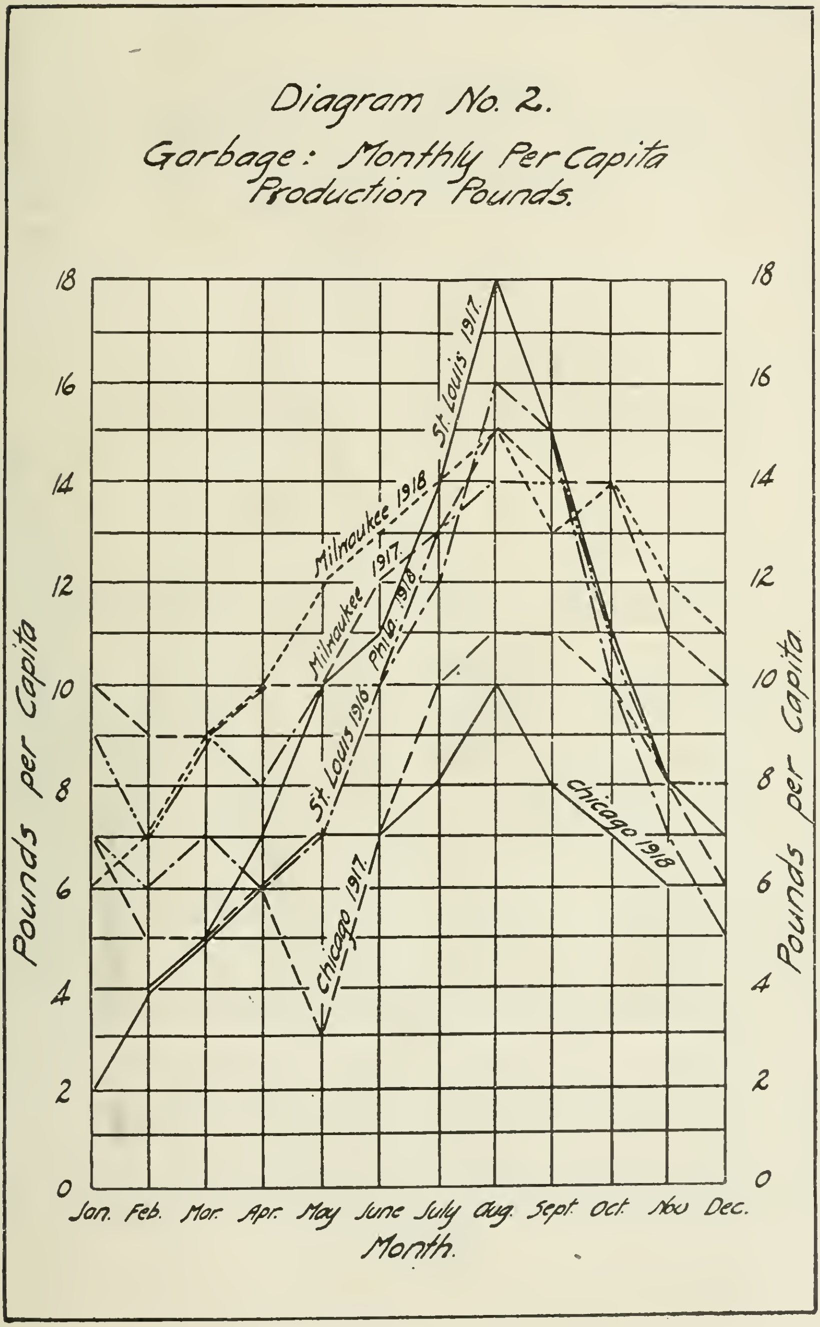

Diagram No. 2.

Garbage: Monthly Per Capita Production Pounds.

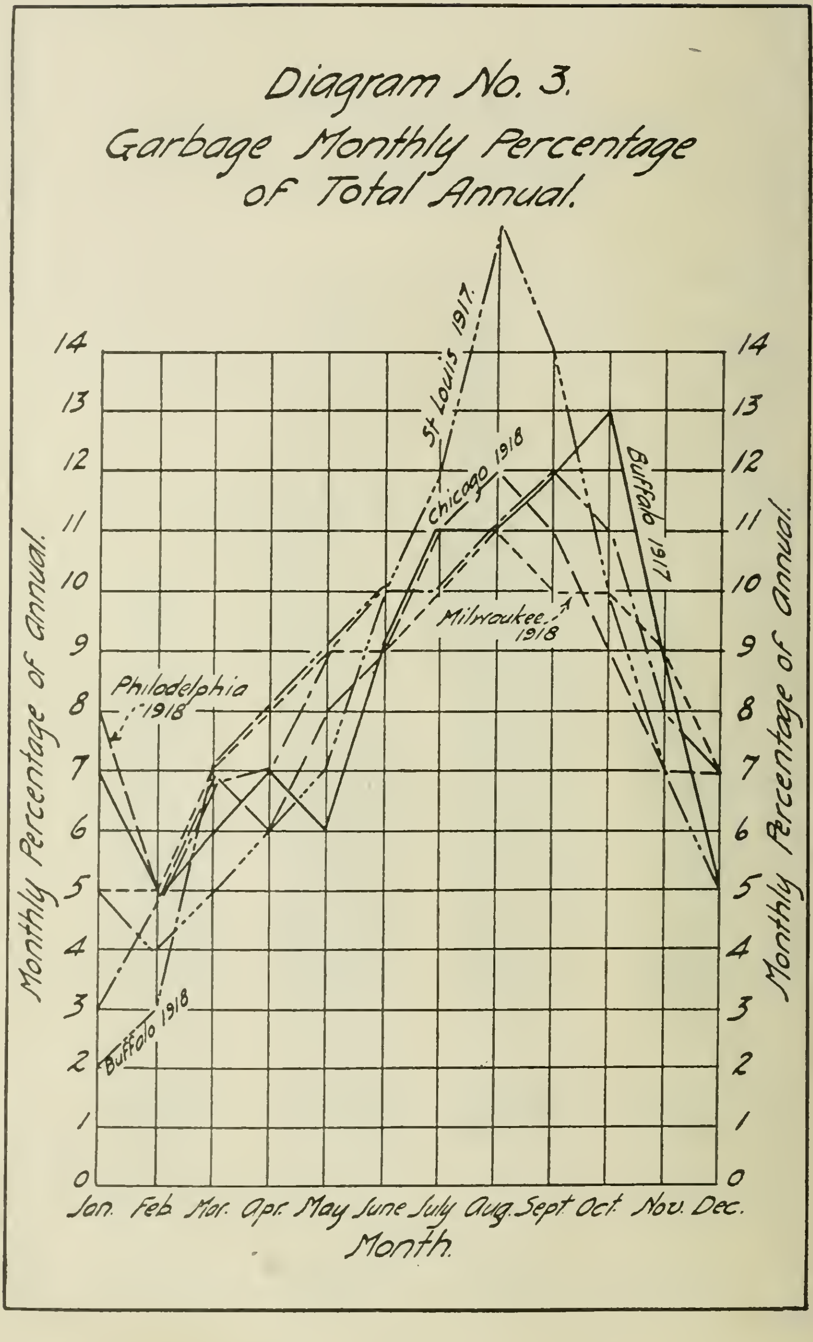

Diagram No. 3.
Garbage Monthly Percentage of Total Annual.

Table No. 2 shows the percentage decrease in the total annual production of garbage to vary from 10 to 30 per cent during the past two years.

In Table No. 3 there is shown the monthly per capita production of garbage, in pounds, for several cities and in Diagram No. 2 the data of this table are reproduced graphically. Diagram No. 3 shows the monthly percentage of the total yearly garbage production of several cities.

TABLE No. 3.—*Monthly per capita production of garbage, in pounds.*

Month.	Milwaukee.		St. Louis.		Philadelphia.	Chicago.		Buffalo.		
	1918	1917	1917	1916	1918	1918	1917	1918	1917	1916
January	6	10	4	7	9	2	7	1	6	9
February	7	9	4	6	7	4	5	2	4	7
March	9	9	5	7	9	5	5	5	6	8
April	10	10	7	6	8	6	6	6	6	9
May	12	10	10	7	10	7	3	7	6	11
June	13	12	11	10	10	7	7	7	6	11
July	14	13	14	12	13	8	10	....	8	11
August	15	15	18	16	14	10	11	....	8	11
September	13	14	15	15	14	8	11	....	9	12
October	14	14	11	10	11	7	10	....	9	11
November	12	11	8	7	8	6	8	....	7	8
December	11	10	7	5	8	6	6	....	4	7

Garbage contains the most valuable properties of any of the municipal wastes. The proportion of fats it contains will vary with the seasonal collection and with the amount of meat used and wasted by members of the community. The grease may be recovered by reduction and the remaining residue, known as tankage, worked up into fertilizer or into feed for animals. Garbage, without any treatment whatever, has some direct fertilizing value when applied to land, but the method of application should be so regulated that the garbage will not be exposed to putrefy on the surface in the air and cause extremely obnoxious odors, nor so placed that the disposal ground becomes a breeding place and the source of the flies of the community.

Fresh garbage, provided it does not contain glass, crockery, clam or oyster shells, or other inedible or poisonous materials, can be fed directly to animals. Fowls will eat certain parts of the garbage, but the amount is too small to serve as a means of disposal for a large community. Hogs are most commonly fed on garbage, but sheep have recently been successfully fed also.

ASHES.

Ashes consist of the material discarded after the combustion of coal or other fuels in household heating and cooking devices, or under the boilers of manufacturing plants. Ashes are usually free from organic matter, unless foreign materials have been mixed with them. In the northern cities, where coal is the chief fuel used, there may be found a considerable percentage of unburned coal in the ashes. In New York City the unburned coal in ashes varied between 20 and 50 per cent, depending upon the district from which the collections were made. In the southern cities where the period of cold weather is shorter, both in intensity and in duration, and where the chief source of fuel is more likely to be wood, ashes will contain a smaller amount of combustible matter, and the unit production will be less. The size of the community and its character will have a marked effect on ash production. In certain sections of the country where gas is available as a source of fuel supply the amount of ashes produced will be extremely low.

Household ashes may be collected separately or mixed with other waste, depending upon the method of final disposition. Industrial ashes are usually disposed of privately, in which case they do not offer a problem for the municipality. In some places ashes from industrial plants are hauled by private collectors to a central loading station and there mixed with the refuse collected by the municipality and disposed of with their wastes collected from the household. In a number of communities no attempt is made on the part of the municipality to collect and dispose of any of the ashes, their removal and disposition being left to the individual.

In mixtures of ashes and rubbish the ashes will make up about 80 to 90 per cent of the mixture, by weight, depending upon the season, class of fuel used, and the character of the population.

The weight of ashes depends to a considerable extent upon the amount of moisture present, which is dependent upon the weather conditions previous to the time of collection. This weight varies from about 800 to 1,500 pounds per cubic yard.

In Table No. 4 there is shown the yearly production of ashes per capita, both in pounds and cubic yards, for several cities.

TABLE NO. 4.—*Annual per capita production of ashes, pounds and cubic yards.*

City.	Year.	Annual per capita production. Pounds.	Annual per capita production. Cubic yards.
Boston, Mass	1917	832	1.02
Do	1916	852	1.04
Do	1915	....	1.02
Buffalo, N. Y	1918	762	.935
Do	1917	668	.810
Do	1916	610	.726
Columbus, Ohio	1918	....	.753
Do	1917	....	.784
Do	1916	....	.726
Do	1915	....	....
Milwaukee, Wis	1918	....	.774
Do	1917	....	.814
Do	1916	....	.756
Do	1915	....	.745
Rochester, N. Y	1918	1,494	1.34
Do	1917	1,471	1.39
Do	1916	1,385	1.30
Do	1915	1,313	1.55
Do	1914	1,444	1.53
Washington, D. C	1919	....	.357
Do	1918	....	.343
Do	1917	....	.414
Do	1916	....	.385

Table No. 5 shows the monthly per capita production of ashes in pounds and in cubic yards, for Buffalo, N. Y., and Milwaukee, Wis. Diagram No. 4 shows the result of Table No. 5 graphically. Diagram No. 5 shows the monthly percentages of the total annual production of ashes.

TABLE NO. 5.—*Monthly per capita production of ashes.*

	Buffalo, N. Y.								Milwaukee, Wis.	
	1915		1916		1917		1918		1917	1918
	Cu. yds.	*Lbs.*	*Cu. yds.*	*Lbs.*	*Cu. yds.*	*Lbs.*	*Cu. yds.*	*Lbs.*	*Cu. yds.*	*Cu. yds.*
January	....	....	0.084	69	0.103	85	0.128	105	0.110	0.025
February	....	....	.074	61	.093	77	.116	95	.122	.095
March	....	....	.111	92	.101	81	.106	88	.093	.140
April	....	....	.079	65	.080	66	.095	78	.082	.133
May	....	....	.065	54	.069	57	.077	64	.065	.085
June	....	....	.047	39	.045	38	.054	44	.052	.047
July	0.037	30	.045	37	.052	42	....	....	.028	.023
August	.035	28	.045	37	.044	36	....	....	.018	.012
September	.036	30	.043	37	.040	34	....	....	.017	.017
October	.042	34	.050	42	.052	43	....	....	.036	.055
November	.054	44	.060	45	.065	54	....	....	.083	.065
December	.079	64	.082	66	.096	79	....	....	.108	.078

RUBBISH.

Rubbish consists of the portion of the household wastes that can not be included under garbage or ashes. Its contents are of a nonputrescible nature, unless garbage has been placed with it, and

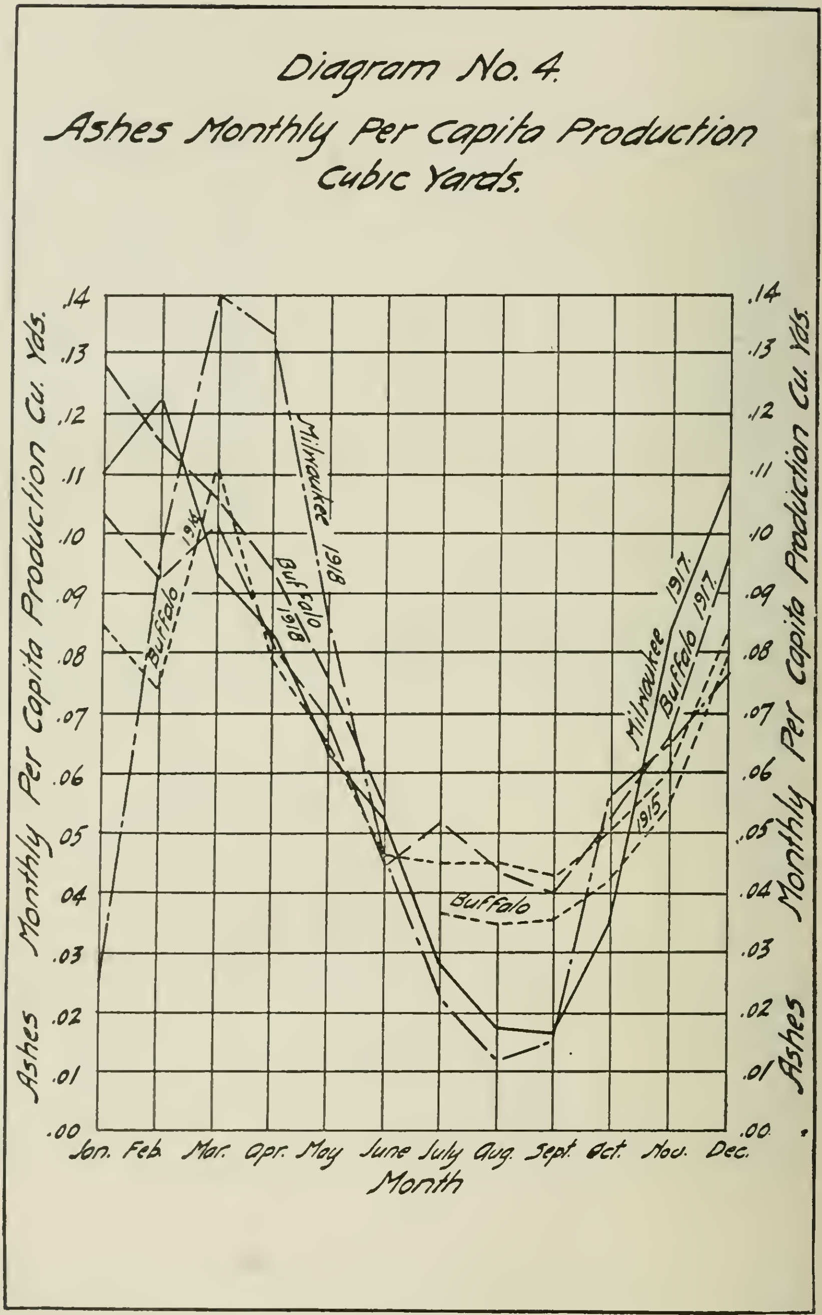

Diagram No. 4.
Ashes Monthly Per Capita Production
Cubic Yards.
Ashes Monthly Per Capita Production Cu. Yds.
.00
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
.11
.12
.13
.14
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Month
Milwaukee 1918
Buffalo 1918
Buffalo 1914
Buffalo
Milwaukee 1917
Buffalo 1917
1915

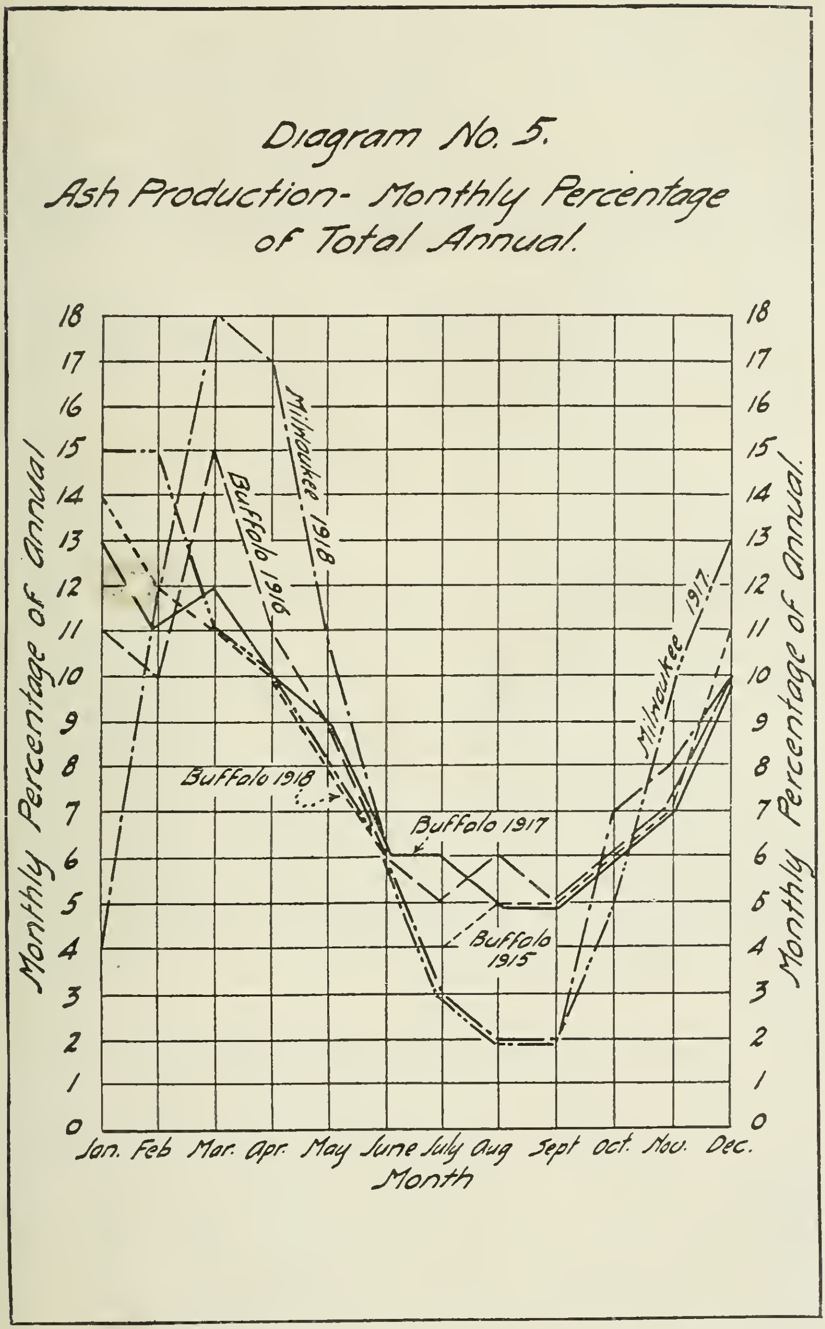
Diagram No. 5.
Ash Production- Monthly Percentage of Total Annual.
Monthly Percentage of Annual
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Milwaukee 1918
Buffalo 1916
Buffalo 1918
Buffalo 1917
Buffalo 1915
Milwaukee 1917
Jan.
Feb
Mar.
Apr.
May
June
July
Aug
Sept
Oct.
Nov.
Dec.
Month

includes paper, wood, glass, crockery, metals, leather, rags, and other discarded household material.

In many cities rubbish is not collected by the municipality, its disposition being left to the individual, who either disposes of it by burning or employing a private collector to carry it to suitable disposal points.

Some cities, where collections of this class of material are made, require no separation of it from ashes, but collect both together. With this combination of rubbish and ashes, disposal is usually made by filling in low places.

Where the disposal of municipal wastes is by incineration, the rubbish is collected mixed with the garbage, the combustible portion of the rubbish furnishing the heat to evaporate the water of the garbage so that it can be burned.

Where ashes and rubbish are collected mixed, the proportions of each will vary, not only with the difference in locality, but in the same city with seasonal variations of temperature. In cities where gas is the source of fuel supply, these variations will not be so marked.

Cincinnati, Ohio, typical of a coal-burning community and where the collection system has been well established for a long time, shows a variation in the percentage of rubbish in the mixed waste, ranging from about 5 per cent in winter to 27 per cent in summer.

The weight of rubbish depends to a large extent upon the amount of water that is contained with the material. The weight of this class of material has been estimated by various investigators, from 100 to 300 pounds per cubic yard. Because of the various conditions of production, the changing character and the lack of sufficient records, the per capita production of rubbish is difficult to estimate. Various cities have reported the yearly per capita rubbish production fluctuating between 36 and 220 pounds. In Table No. 6 there is shown the annual production, per person, in pounds, the material classed as rubbish in Buffalo, N. Y., Boston, Mass., and Rochester, N. Y.

TABLE NO. 6.—*Rubbish, annual production pounds per capita.*

City.	Population.	Year.	Total tonnage.	Per capita pounds.
Boston, Mass	781,600	1917	8,130	21
Do	762,300	1916	10,744	28
Buffalo, N. Y	473,200	1918	19,871	84
Do	465,800	1917	23,163	100
Do	478,300	1916	29,881	125
Rochester, N. Y	264,900	1918	7,394	56
Do	264,700	1917	8,180	62
Do	256,400	1916	11,534	90
Do	250,700	1915	12,051	95
Do	241,500	1914	10,350	86

Rubbish contains material that has a commercial value, which may be salvaged, if unmixed with other wastes that do not make the cost of sorting prohibitive. Among these materials may be mentioned bottles, rags, paper, metals, leather, rubber, and wood.

The city of Buffalo, N. Y., has for a considerable time, maintained a so-called utilization plant. Salvageable material is recovered and sold, while the remaining combustible material is burned, the heat furnishing steam for one of the sewage pumping stations near by. A small portion of the city garbage is hauled to this plant and burned, which represents a saving, as the garbage is disposed of by a private concern to which the city pays $1 per ton. The expenses of operating the Buffalo plant for the past three years and the revenue derived from the sale of material, steam, and the saving represented by the burning of garbage have been as follows:

Buffalo Utilization Plant.	1916	1917	1918
Pay roll	$44,489.61	$44,666.20	$48,689.58
Maintenance and repairs	16,523.60	7,764.23	5,711.78
Interest	2,240.00	1,840.00	1,440.00
Total expenditures	63,253.21	54,270.43	55,841.36
Revenue:			
Sale of material	55,117.09	55,184.21	47,153.31
Sale of steam	4,235.18	3,874.15	8,560.24
Saving from garbage disposal	4,946.94	1,733.70	712.57
Total revenue	64,299.21	60,792.06	56,426.12
Profit on operation of plant	1,046.00	6,521.63	584.76

In connection with the sorting of city rubbish, it is interesting to note the amount of material that has a sale value and the revenue obtained from it. The following figures cover the operation of the Buffalo plant for the period July 1, 1917, to June 30, 1918. The estimated population of the city during this period was about 473,200. The total rubbish collected 19,871 tons, equivalent to about 84 pounds per capita.

2,939,231 pounds newspaper	$10,287.38
6,785,680 pounds mixed paper	20,357.28
811,682 pounds manila paper	4,464.27
103,800 pounds rags	1,927.62
2,015 pounds flour bags	30.23
1,490 pounds charcoal bags	22.35
1,327,976 pounds of tins	4,165.48
204,440 pounds broken glass	630.62
275,077 mixed bottles	1,836.50
144,846 beer bottles	1,189.83
138 beer crates, wood	13.15
38 beer crates, iron	7.15
721.57 tons garbage destroyed	712.57
63,963 pounds old shoes	267.46
13,440 pounds metal ware	31.50

15,885 pounds scrap iron	$122.23
13,980 pounds granite ware	32.77
8,000 old electric bulbs	32.00
24,840 pounds of wood ashes	62.10
30 jugs	.60
Fire loss adjustment	1,670.00
Miscellaneous	2.79
Total material	47,865.88
Steam furnished Hamburg Pumping Station, 4,115½ hours, at $2.08	8,560.24
Grand total	56,426.12

The destruction of garbage represents a saving of $712.57, as otherwise this would have been paid by the city to the contractor for its disposal.

At Columbus, Ohio, the rubbish is sorted—for material of value, but no additional power other than that required to operate the plant is derived from the combustible material. The operations are on a much smaller scale than at the Buffalo plant. During the years 1917 and 1918, the operating expenses of the plant were $3,274.49 and $3,323.24, respectively, while the revenue derived from the sale of recovered material during the same years was $3,505.37 and $3,914.10, the profits amounting to $230.88 in 1917 and $590.86 in 1918.

Figures for the operation of the Rochester, N. Y., sorting plant, taken from reports furnished by the city, show the cost of operation and the revenue derived from the sale of recovered material to be as follows:

	1918	1917
Operation.		
Labor	$26,406.96	$20,350.52
Supplies	6,069.79	3,314.82
Salaries	5,704.50	4,820.00
Truck maintenance	1,253.27	....
	39,434.52	28,485.34
Revenue	16,401.16	19,070.24
Cost of disposal	23,033.36	9,415.10
Tons collected	7,394.3	8,198
Cost of plant operation per ton	$5.33	$3.47
Income per ton of rubbish	$2.22	$2.33
Cost of disposal per ton	$3.11	$1.14

ASHES AND RUBBISH

In communities where ashes and rubbish are collected together the yearly percentage of the ash content will run between 80 and 90 per cent and the rubbish between 20 and 10 per cent. The relative proportions of ash will, of course, fluctuate during the months of the year, the ashes being higher in the colder months and lower in the warmer months. At Buffalo, N. Y., the collection of ashes and rubbish is made separately. In Table No. 7 are shown data relative to the mixed wastes containing both ashes and rubbish collected at Buffalo.

TABLE NO. 7.—*Total and unit quantities of rubbish and ashes collected annually, Buffalo.*

	1917–18	1916–17	1915–16
Population	473,200	475,800	478,300
Ashes, cubic yards	442,312	385,016	345,696
Rubbish, do	186,245	209,625	258,916
Ashes, tons	181,523	175,979	141,914
Rubbish, do	19,871	23,163	29,881
Ashes, per cent	90	87	83
Rubbish, do	10	13	17
Ashes (cubic yards per capita)	0.935	0.810	0.722
Rubbish (cubic yards per capita)	.39	.44	.54

In Table No. 8 are given additional data relative to the annual production, per person, of the mixed wastes, rubbish and ashes.

TABLE NO. 8.—*Annual per capita production of ashes and rubbish.*

City.	Year.	Cubic yards.	Pounds.
Boston, Mass	1917	....	879
Do	1916	....	872
Columbus, Ohio	1918	0.77	....
Do	1917	.45	....
Do	1916	.70	....
Milwaukee, Wis	1918	.78	....
Do	1917	.80	....

The weight of rubbish has been estimated by H. de B. Parsons (The Disposal of Municipal Refuse, 1906) as 200 pounds per cubic yard and that of ashes as 1,350 pounds per cubic yard. In the mixed refuse consisting of ashes and rubbish, the weight will vary between 1,120 and 1,235 pounds, per cubic yard, depending upon the season of the year.

RUBBISH AND GARBAGE

In many cities, municipal incinerators are used for the disposal of the wastes. Where this form of disposal is in practice, rubbish and garbage are usually collected together, without separation, and burned at the incinerator, while the ashes are collected separately and disposed of by dumping on fills.

The combustible material contained in the rubbish is utilized to generate sufficient heat to evaporate the water content of the garbage so that the organic matter will burn.

In Table No. 9 there are shown data relative to the total annual tonnage of the mixed waste, rubbish and garbage, delivered at incinerating plants for disposal.

TABLE NO. 9.—*Annual per capita production of rubbish and garbage, in pounds.*

City.	Population.	Year.	Total annual production.	
			Tons.	Pounds per capita.
Charleston, S. C.	62,000	1918	18,936	612
Savannah, Ga.	69,300	1917	22,400	676
Do.	68,900	1916	26,422	767
Do.	68,500	1915	27,661	806

In Table No. 10 there is shown the monthly variation, in pounds per capita, and the monthly percentage of the total annual production of the mixed waste, rubbish and garbage.

TABLE NO. 10.—*Monthly per capita production, in pounds, of rubbish and garbage, and the monthly percentages of annual production.*

	Charleston, S. C.		Savannah, Ga.			
	1918		1916		1915	
	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.	Per cent.
January	45	7	69	9	69	9
February	43	7	64	8	61	7
March	43	7	60	8	63	7
April	46	7	54	7	62	8
May	48	8	56	8	61	8
June	49	9	54	7	58	7
July	60	10	98	13	90	12
August	62	10	85	11	82	10
September	56	9	53	7	59	7
October	59	10	53	7	65	8
November	52	8	56	7	60	8
December	53	8	61	8	69	9
Total	616	100	763	100	799	100

In southern communities, the proportion of garbage increases very decidedly during the months of July and August, when the melon season is at its height. During these months it sometimes becomes necessary to collect ashes to mix with the garbage to absorb moisture, in order that the rubbish can be made to burn it. The various proportions in the mixture of rubbish and garbage on an average will be, rubbish 50 per cent, ashes from 5 per cent in summer to 10 per cent in winter, and garbage 45 per cent in summer and 40 per cent in winter.

DEAD ANIMALS.

As a class of waste, this usually consists of the larger animals, but where complete collection is practiced, is made to include the smaller animals also. In addition to municipal collection, there are usually, in the larger cities, private rendering companies, that pay a nominal sum for the bodies of the larger animals, and make collections with their own equipment. In these places the collection of the smaller animals is left to the municipality and is usually done by the garbage department. In some very few instances the municipality may pay a small sum for the dead animal. St. Louis, Mo., in 1916 collected about 3,000 horses, 384 mules, 8,740 dogs from the pound, and 150 other animals; in 1917 about 2,500 horses, 258 mules, 10,770 dogs, from the pound and from the streets, and 178 smaller animals.

Milwaukee, Wis., employs a permanent collector the entire year and an additional one during the warm months. The wages paid are at the rate of $4.50 per day. During 1918 the collection of small animals amounted to 3,903 the cost of collection averaging $0.47 per animal. In 1917 the wages paid were at the rate of $4 per day, and 4,446 animals were collected at an average cost, per animal, of 0.41.

STREET SWEEPINGS.

Street sweepings consist of the material, in the form of dust, worn from road surfaces by the abrasive action of traffic passing over them, horse droppings, and a mixture of other materials, such as matches, paper, fruit skins, and small boxes, thrown into the streets by persons using the sidewalks or dropped from vehicles passing through the streets. In some communities it is common practice for business establishments to deposit sweepings from the floors and sidewalks into the gutters of the streets, which accounts for the miscellaneous assortment of foreign material contained in street sweepings from some localities. In the fall of the year the quantity of this waste may be very materially increased by leaves in those sections that are laid out with shade trees.

Catch-basin cleanings consist of the heavier settleable materials from the streets that are washed into and settle out in these basins during the flushing of the streets or during times of rain.

The increased use of the automobile with its rubber tires has reduced the amount of wear upon the pavements and has reduced the amount of horse droppings contained in street sweepings, but has increased the amount of oil and grease in this class of waste material.

Street sweepings will vary in composition with the character of the community, the kind of road surfacing, and with the efficiency in collection of the other classes of municipal wastes.

Analyses of street sweepings from the larger cities show approximately the following variations in the proportions of the constituents:

	Per cent.
Moisture	44 to 29
Ash	42 to 48
Combustible matter	14 to 23

Kjeldahl nitrogen; potash, as K_2O, and phosphoric acid, P_2O_5, will make up about 0.5 per cent of the total.

Street sweepings are combustible. Determinations made in Ohio give the calorific value varying between 1,443 and 2,132 units.

Street sweepings do not contain, usually, sufficient putrescible organic matter to preclude their use for filling low areas, that later may be used for building sites, playgrounds, or parks. The amount of finely divided material that they contain may, however, cause disagreeable conditions from dust in the vicinity of the place of dumping. Street sweepings weigh from 800 to 1,400 pounds per cubic yard.

EXCRETA.

Excreta are usually classed among the municipal wastes under the head of sewage and treated with that subject. Its nature is such that water and soil pollution may occur on the premises or at the point of disposal, that the carting of such material through the streets is liable to create nuisances, that its proper care and disposal becomes a problem which affects the health of the community as a whole, and as such should be under the supervision and control of the municipality.

Excreta, frequently designated as "night soil" because collection of it formerly was made at night, is like sewage in character, but has a lesser water content and more resembles sewage sludge. Excreta as collected may contain, in addition to the feces, urine, and paper, many materials of household origin, such as glass, crockery, rags, ashes, sticks, and metals. The liquids contained in the mixture vary with the method of storage on the premises. Where the surface privy, pit, or leaching cesspool is in use, the liquids will have a chance to leach into the soil, possibly into the water supply, leaving a more or less thick, sludgy mass that can almost be shoveled. In the water-tight methods of disposal the liquids are retained and the mass is fairly liquid in consistency and its removal can be accomplished by pumping.

In some communities no attempt is made to collect this class of waste, its disposal being left to the individual, who either gets rid of it by burial near the source of production, or hires a private collector to remove and dispose of it. In other places the type of privy is such that collections must be made regularly once each week, and in some of these the municipality operates the scavenger service, for which a monthly charge is collected from the householder.

To insure a higher grade of sanitation, collections of excreta should be made during the day. With plenty of light, the places to be cleaned or the receptacles to be emptied are more easily located, yards can be more easily entered without interference from dogs, the cleaning operations are more easily performed, with less chance of scattering the material about, and noise is less noticeable. With night cleaning, the disposal area or the disposal plant should be lighted, which is an added expense, to insure proper and cleanly methods. Proper wagons and other equipment are now available, so that with proper operation on the part of the scavenger odors can be reduced to a minimum and the carting of such material through the streets is not a serious objection.

Data on the amount of excreta produced per family and per person have been obtained at Hampton and Phoebus, Va., where the excreta are collected in pail receptacles and dumped into specially designed plants for its treatment. Measurements of the contents of a considerable number of the pails arriving at these treatment plants have shown that there is a slight seasonal variation, due to changes in diet, and that there appears to be a difference in the amount of excreta produced between white and negro families, due to the difference of living conditions. The average production of excreta per family of five appears to be about 3.5 gallons per week, or 0.1 gallon per person per day. Of the five persons represented by these families, two and sometimes three are away the entire day, at work or at school, and have access to other methods of sewage disposal. The figures given, therefore, represent the average amount to be expected for collection and disposal rather than the total amount produced.

Excreta weighs approximately the same as water—62.5 pounds per cubic foot, or about 1,690 pounds per cubic yard.

While there undoubtedly is some fertilizer value in excreta, the methods of disposal are such that very little of this value is utilized in this country.

Disposal of excreta is by dumping into existing sewer systems, through suitable manholes where one is available, by burial on land, and in a very few instances by incineration.

STABLE MANURE.

Stable manure consists of the straw or other material used for bedding, combined with horse manure and saturated, more or less, with urine. The amount is fairly uniform as to constituency and amount. The mixture weighs approximately 670 pounds per cubic yard, depending to a very great extent upon the amount of moisture present.

Stable manure has a market value and as a fertilizer has a ready sale. In a large number of communities, no attempt is made to collect or dispose of this waste systematically. In most instances the individual either uses it on land of his own near the point of production or sells it to the farmers to be hauled into the country to be used as a fertilizer. When left to the farmer to collect, removal is uncertain, especially in the summer months, when fertilizer is not particularly needed on the farm, and when crops have to be harvested and marketed. At this time of the year collection should be particularly regular, as the fly season is at its height, and stable manure forms an ideal breeding place for these insects. For these reasons, the systematic collection and proper disposal of stable manure is beginning to demand municipal attention.

The city of Columbus, Ohio, maintains a partial collection service for the removal of stable manure. Upon payment to the city treasurer of $3 for one horse, $5 for two horses, and $1 for each additional horse, the manure collection division is notified, on a form, which states the owner's name, the address of the stable, and the number of horses. Each of the three drivers of the collection service is given a separate list of barns to collect from and each night reports the places that have been collected from during the day. The income from the sale of permits, together with the price received from the sale of the manure, is sufficient to pay for the cost of collection.

COLLECTION OF MUNICIPAL WASTES.

SEPARATION OF WASTES.

Of the municipal wastes, consisting of garbage, ashes, rubbish, dead animals, street sweepings, excreta, and stable manure, the last four classes are in all instances collected separately. The municipality is not usually called upon to collect and dispose of stable manure, inasmuch as it has a commercial value as fertilizer, which can be realized upon by the owner and therefore, is, in most cases, disposed of privately. Street sweepings are collected more frequently than the other classes of waste, usually at a different time and in most instances by the street department, which maintains its own equipment. The disposal may or may not be in the same manner and at the same place as that of the other waste. Excreta, because of its extremely offensive nature, is always collected separately, in specially designed wagons. In most cases the city maintains no collection system for the removal of excreta, but licenses private scavengers for the work, who collect under regulations made by the health department. Dead animals are collected separately, by special wagons, operated by the garbage department or by private companies. Of the first three classes of waste (garbage, ashes, and rubbish), collections may be made separately or in various combinations, depending upon the method of final disposal.

The collection practice relative to garbage, ashes, and rubbish may be summarized as follows:

Garbage only is collected in the smaller communities, where the necessity for regular and efficient collection of the other wastes has not been realized, or because funds are not available to collect all of the classes. The individual disposes of the other wastes by private collectors, usually at a greater cost than if collections were made by the municipality. The garbage is disposed of by burial, feeding, or incineration.

Garbage and combined ash and rubbish collections.—Used with nearly all methods of disposal. The garbage is incinerated, buried, or used for feeding, and the ashes and rubbish disposed of by filling.

Ashes and combined garbage and rubbish collections.—This method of separation is practiced where incineration is used as the method of disposal. The garbage and rubbish are burned in the incinerator and the ashes are used for fills. In some instances the furnace ashes and stove ashes are separated. The stove ashes contain some combustible material and are an aid to incineration, while the furnace ashes are placed in the fills.

Separate collections of garbage, ashes, and rubbish.—The garbage may be disposed of by reduction, feeding to animals, buried, or burned. The ashes go to the fills. Rubbish may be sorted on the dumps, carted to a utilization plant, where the salable material is sorted out and the remainder burned. The ashes and rubbish may be dumped together on the fills.

Combined collection of garbage, ashes, and rubbish.—The method of disposal is by incineration or by filling low areas.

Garbage should be kept in water-tight, nonabsorbent, covered receptacles. These requirements prevent pollution of the soil in the vicinity of the point of storage, keep the receptacles from becoming saturated with decomposing liquids, exclude rain water, retain odors, and prevent the access of animals. The capacity should be such that the material can be stored between times of collection, but not of such size that a man can not lift the cans. In most cases a galvanized iron pail, with cover, of between 9 and 12 gallons capacity is specified.

Ashes should be stored in a noncombustible receptacle, which is tight. Covers are not generally provided but are very desirable to prevent dust. Barrels are the most common container in use. Boxes of various size and shape are also very commonly met with. The capacity should be such that the container can be lifted, namely, from 150 to 200 pounds.

Rubbish is generally stored in any kind of a container that can be conveniently handled.

Where the pail system of excreta disposal is in use, each privy is provided with one or more pails. Collections are made every week with specially designed wagons. The full pail is covered, placed on the rack wagon, and a clean, empty, disinfected pail left in its place. These excreta pails have a capacity of about 9 gallons and are easily handled by one man. In some communities the pails are emptied into the collecting wagon which is water-tight and covered. This method is not as satisfactory, in that the pail is replaced in a dirty condition, odors are disseminated when the pails are emptied and the wagons are not always maintained in a water-tight condition.

COLLECTION OF WASTES.

For the proper and efficient collection and disposal of municipal wastes, there will be required:

1. Rules and regulations by the municipality, covering methods for the proper conduct of the work.
2. An appropriation for carrying on the work.
3. An efficient organization to carry on the work.
4. Sanitary and economical methods for conducting the work.
5. Cooperation by, and the education of, the public.

1. In the operation of an efficient collection system, certain rules and regulations governing the separation of wastes must be made and enforced; for instance, the receptacles to be used, the method of placing the wastes in them, such as draining the garbage or wrapping it in paper, the point where the receptacle should be placed for collection, time at which collections will be made, equipment to be used, and the method and place of disposal. Without such regulations all manner of mixed wastes will be collected, which will seriously interfere with their proper disposal. The location of disposal areas or plants should be determined upon first, and the separation of wastes best suited for the method adapted should be enforced. Receptacles should be uniform in character, water-tight and covered, for garbage and of a capacity sufficient to store the material between the periods of collection. For ash containers certain requirements should be made, especially as to weight. If too heavy for lifting, they will have to be dumped upon the street and shoveled into the collecting wagons, all of which requires time and is conducive to much dust. Collections should be at specified times and should be made at such times, enough equipment being provided to accomplish it. Where the receptacles are placed at the curb line by the occupant, their storage on the streets, waiting a day or so for the collecting wagon to put in an appearance, is not an attractive sight. The householder is put to inconvenience for lack of storage place and animals have access to the containers on the street. Where the collections are made from the premises, collection at exact and stated times are not of so much importance. Collections of garbage should be made in water-tight wagons and the material should be covered. Ash and street sweeping wagons should be covered to prevent dust blowing about the streets. This may also apply to rubbish wagons, but the volume of fine material is much less and tends to settle to the bottom. For excreta collection, the wagons should be water-tight and as near air-tight as possible.

If the collection of wastes is let by contract, the city should see that these regulations are lived up to by the contractor, and if the collections are made by the municipality such equipment should be provided. Careful selection of points of disposal and methods should be made, due regard being given to length of haul, distance from nearest dwellings, and the liability of nuisance from the method selected. Supervision over disposal should be exercised at all times, in order that the process may be carried out with maximum efficiency.

2. The collection and disposal of wastes represents an expenditure of funds. Certain methods of disposal may be employed to pay for this (disposal) part of the system and assist to a very small extent in defraying the cost of collection, but there is no known method of disposing of municipal wastes that will cover both the cost of collection and disposal. The municipality will, therefore, be called upon to provide money for the operation of the collection and disposal systems. The efficient removal and proper disposal of waste represents a convenience for which the householder should be willing to pay a reasonable sum, which in most cases will be less than if such material is disposed of by the individual.

3. For efficient service, a suitable and flexible organization must be built up, either by a contractor, if the work is done by this method, or by the city.

Where the work is performed by contract, definite specifications should be drawn up, covering all phases of the work to be performed and obligating the contractor, under bond, to supply the service specified. The contractor must maintain the organization and equipment to render efficient service and it should be the duty of the city authorities, by the aid of proper supervision, to see that the terms of the contract are complied with. The length of contract has a very marked effect on the efficiency and cost of collection and disposal. With short-time contracts, the price paid must either be excessive, to cover the cost of the investment for equipment, or else the equipment supplied will be exceedingly poor.

Where the collections are made by the municipality, the time element does not enter into the problem, investments are permanent, better equipment can be provided, and the work can be planned more systematically, looking toward the future. The city has the necessary legal authority to enforce the regulations which is lacking on the part of the contractor. The men employed are responsible to their direct supervisors and changes in methods can be made for better service on short notice. Under contract, certain work and the method of doing it are specified, while under municipal control, changes can be made as different conditions arise. In the majority of cases in this country, collections are made by the municipality.

4. Sanitary and economic methods of conducting the work of collection and disposal depend almost entirely upon equipment used, the authority that the municipality has over the men conducting the operations and the supervision exercised over the methods. For such service the teams are best owned by the city, rather than hired; the men should be city employees responsible and subject to the orders from a supervisor, who in turn is responsible to the public to render efficient service.

5. For the proper conduct of waste removal and disposal, cooperation between the householder and municipality is essential. The people are under certain obligations to the municipality and the municipality to the people. The city should make collections at convenient hours, regularly and with sufficient frequency. No damage should result to property, and the material should not be scattered over the yards or along the streets. Wagons should be properly maintained in order that nuisances will not be created. The employees should remember that they are servants of the public. In some cities, in order that the householder may obtain efficient service, it becomes necessary to fee the collectors liberally, otherwise waste is scattered over the yards and sidewalk, receptacles receive rough handling, may be left at the curb when they should be returned to the yard, or collection may be skipped altogether. This is a state of affairs that should not be tolerated in any community and should be stamped out at its beginning. It should be impressed upon the employees that their duties are important and upon them to a certain extent rests the proper sanitation of the city.

The people should be informed by the municipality of the rules and regulations relating to collection and disposal of wastes, in order that they may make the necessary separations, provide adequate and standard receptacles, place them at the stated times at the required places, and cooperate with the collection forces.

METHODS OF COLLECTION.

Methods of collection depend primarily upon the separation required and the method selected for disposal. Where garbage is collected separately to be fed to animals, it should be received at the feeding farm as fresh as possible. This requires daily collections in summer, in warm climates, and alternate days in winter. In the northern climates, collections every other day in summer and twice a week in winter may be sufficient. Where separated garbage is to be rendered, frequency of collection, as affecting the final treatment, is not as important, but should not be left for such a length of time as to cause nuisances at the point of storage on the premises.

Where ashes and garbage are mixed, the ashes absorb the liquids of the garbage, odors are eliminated to a certain extent, the fly problem is reduced considerably and collections may be made less frequently.

The collection of ashes depends almost entirely upon the convenience to the householder. In winter, a barrel of ashes will be produced about every one to three days with furnaces in operation; in summer with only cooking apparatus in use, a barrel will be produced in perhaps one to two weeks. Collections should therefore be made so that large accumulations do not collect on the premises.

While no regular collections are made in most instances by the municipality, fresh stable manure should be removed from the premises at least every four days, as but four days are required from the time the eggs are deposited until the maggots begin to migrate from the manure heap into the ground to continue their development into full-grown flies.

The frequency of the collection of excreta depends upon the size of the receptacle in which it is stored. As one extreme, there is the earth pit, with a large capacity, sufficient for a year's use, which may be filled in with earth at the end of that time or the contents removed. On the other hand the pail system of excreta disposal has a capacity of about one week's use for a family of five and collections are necessary once every week.

The placing of receptacles for emptying varies in different communities. In some places the containers are placed on the sidewalks at the curb line, in some on the lot just inside the fence line, in some in the alleys, and in some in the rear of the house. Many city ordinances state that the location shall be convenient for the collector.

Where an ordinance is in force requiring that receptacles be placed at the curb line or on the alley, one man can be employed to make the collection by simply passing along the street or alley and dumping the contents of the receptacle into the wagon. There is considerable difficulty in enforcing an ordinance of this kind, especially in the foreign section of a community. If collections are not made close to stated times, cans may be missed or they may be left on the street for a day or longer.

Where the yards have to be entered, some cities employ two helpers besides the driver of the collecting wagon. One helper precedes the wagon, setting the receptacles at the curb line, the driver empties them into the wagon and the second helper brings up the rear, replacing the receptacles in the yards. Where garbage is separated and collections are from the premises, the driver may be provided with a fairly large sized pail, into which he empties the contents of the house receptacle, thus eliminating a return trip with the empty pail.

In a limited number of cities, where collections are made by contract, the receptacles are supplied to the householder free of charge. In such cases a charge of about 10 cents per collection is made. The full pail is placed on a specially designed wagon and a clean empty pail left in its place.

Ashes and rubbish are usually emptied directly into the collecting wagon at the curb line. The receptacles may or may not be placed at the curb line by the occupants. In one city, at least, the unusual condition of entering the basements for the collection of ashes is met with.

A garbage wagon should have a water-tight body, with a smooth interior of nonabsorbent material, without cracks or projections that will retain and accumulate garbage, that can be easily dumped and flushed. It should be built low to make emptying of receptacles easy, provided with a cover, and should be well-constructed. There are several types of garbage wagons, some fulfilling many of those conditions and some a few of them.

The most common is the steel-body wagon with the rear sloping to make dumping easy, built in one or two horse sizes. In some cities a metal wagon-body is in use that can be entirely removed from the running gear by a crane and transferred by truck or rail to the point of disposal. The capacity of these wagons is about 2½ cubic yards. In some instances a metal-lined, wooden box is used that requires emptying by shoveling. Many private collectors use water-tight barrels on a platform wagon. This method is not entirely satisfactory as the barrels, if not carefully covered (and in most instances they are not), will slop over in transit. The capacity of garbage wagons is about 2 cubic yards for the single-horse type, to about 3½ cubic yards for the two-horse type. Auto trucks hold as much as 10 cubic yards. At a few places, where private collectors own the cans, the collecting wagon consists of a single or double platform wagon upon which the full cans are placed and emptied at the disposal plant. The capacity of such wagons varies from 30 cans for the light wagons, up to 60 cans for the heavy wagons. Similar wagons are used for collecting the pails where the pail system of excreta disposal is in use. Garbage wagons should be covered during transit, but this seems to be a difficult requirement to enforce unless there is efficient supervision exercised over the collection system.

The requirements for an ash wagon are dust-tightness rather than water-tightness, a usable cover to prevent dust from blowing about the streets, an easy method of dumping, construction to facilitate the dumping of heavy ash barrels, and durability. Where ashes and rubbish are mixed, practically the same type of wagon is required, as the ashes will make up from 80 to 90 per cent of the mixture. Tailboard dump carts, bottom dump wagons, dump pole wagons, and ordinary box wagons are in use. The capacity of one-horse wagons is usually about 2½ cubic yards and for two-horse wagons 4½ to 5 cubic yards.

Rubbish wagons can be much lighter than ash wagons, as the material is lighter, bulkier, and does not pack solidly. Its consistency is such that a rack wagon, with a small tight bottom to catch the small amount of fine material, can be used. The sides can be higher than on the ash carts, as the material does not weigh as much and the capacity can be increased up to 10 or 15 cubic yards.

In some cities special wagons are provided in the business districts to collect papers only. These vary in capacity from 5½ to 8 cubic yards.

As an illustration of the equipment required in a large city for the collection of garbage, ashes, and rubbish, the following figures are taken from the 1917 report of the public works department of the city of Boston. The population in the collecting area is approximately 782,000.

Type of wagon.	Number in use.	Capacity.	
		Pounds.	Cubic feet.
Single ash carts	171	2,037	67.5
Double ash carts (city)	8	3,270	108
Double ash carts (contractors)	40	4,075	135
Paper carts	15	1,400	146
Paper wagons	19	2,200	219
Single offal wagons	71	2,360	54
Double offal wagons	47	4,130	94
Automobiles	3	8,150	270

The force employed on waste removal during the year 1917 was as follows:

Inspectors	37
Teamsters	249
Helpers	389
Dumpers	1
Total	676

COST OF COLLECTION.

So many conditions enter into and influence the cost of collection that the costs for a community contemplating starting a new system can not be estimated with any degree of certainty from figures derived from a community where a system is already in use, unless conditions are very similar.

The cost of collection is influenced by (1) cost of house-to-house collection and (2) cost of haul to the place of final disposal.

Factors influencing the collection costs are location of the receptacle, whether placed at the curb or whether collections have to be made from the premises, the number of collections weekly, the number of collectors employed with each wagon, whether separate or combined collections, unit amounts produced, character of the population, density of population, labor costs and amount of supervision. The cost of haul will be influenced by distance to disposal point, topography, condition of roads, grades, capacity of wagons, cost of operating equipment, whether city owned or hired, and method of disposal.

The most efficient and economical method of collection for each community will have to be worked out by trial and careful keeping of cost data.

Up to within the past three or four years the general consensus of opinion has been that it was cheaper to make house-to-house collections with horse-drawn vehicles, rather than with motor trucks, but that motor trucks were more economical for the longer haul after the collection had been made. The combination of the two methods, using horse-drawn wagons for collecting and delivering to a central loading station, from which the haul could be made by truck to the point of final disposal, would appear to be the most economical.

During the past two years, however, the cost of operating horse-drawn vehicles has increased materially, due to increased first cost of horses, cost of grain, hay, and bedding, and higher cost of labor, both at the stable and on the wagons. The cost of hired teams is necessarily higher than city-owned teams, as a legitimate profit should be allowed the contractor on his investment.

With the increased cost of keeping or hiring horses, it now appears to be a question to be solved by each individual community whether or not collections can be made more economically by horse or motor vehicles.

Several cities keep accurate and fairly complete records of the cost per horse of maintaining city-owned stables. The average cost per horse per day for four of these cities appears to be in the vicinity of $1.25, which includes feed and bedding, cost of shoeing, veterinary care, stable labor, and harness repairs. To this figure there should be added interest on cost of horses, depreciation, replacements, interest and depreciation on stable site and buildings, or stable hire. From available data, these items have been estimated at $80 per horse per year. Where wagons are being operated there should be allowed a charge for repairs and depreciation upon them, which has been estimated at $45 per year. A driver's wages are assumed at $3.50

per day for a year of 310 working days. With these figures as a basis, the cost of a single team would be about $4.57 per day and of a double team $6.16. If the cost of hired teams is much in excess of these figures it might be more economical for the municipality to maintain its own equipment.

The Chicago Efficiency Division, in a report made public in July, 1915, states that gasoline and electric trucks should be used for hauling from a loading station, after the house-to-house collections have been made with horse-drawn carts costing $5.50 per day or less. Should the cost of horse-drawn carts be increased, the motor trucks would be slightly cheaper, but the complete change of equipment would not be advisable. Between gasoline and electric trucks, the latter were found to be more economical. The haul below which a 3-ton truck would not be economical, when measured against a $5.50 per day cart, was 1.8 miles; against a $6 per day cart, 0.8 mile. Three-ton gasoline trucks were found to be not as economical as either a $5.50 or $6 cart. The cost of operating the 3-ton gasoline and electric truck was estimated as $10.73 per day for gasoline trucks and $9.64 for electric trucks on a basis of 25 miles per day. First cost and fixed charges on both classes of truck were practically the same at $6.30 per day. Variable charges per mile were estimated as $0.1767 for the gasoline truck and $0.1340 for the electric.

In Los Angeles, Calif., motor trucks are used for collecting non-combustible refuse. Two 2½-ton trucks are used on hauls averaging over 8 miles. The crew is comprised of a driver and two helpers and the usual collection is two loads per day. For the remainder of the city, on short hauls, horse-drawn carts are still in use. The cost of collection on the long hauls with the motor trucks is given as $2.76 per ton, against $2 per ton for the short hauls with teams.

The Rochester Bureau of Efficiency estimates that the cost of operating a 3½-ton truck would be $12.69 per day, that such a truck would collect 36 cubic yards of refuse, which would make the cost 35.3 cents per cubic yard, against a horse-drawn cart collecting 20 cubic yards per day at a cost of 30 cents for hired teams and 28.3 cents with city teams.

The city of Philadelphia, Pa., is operating ten 5½-ton trucks on the collection of ashes. Eight test trips showed that in collecting loads, the average number of receptacles emptied was 318, varying between 298 and 332. From the test trips, the cost of collection is given as $19.15 per day or an average of 31.9 cents per cubic yard, on a basis of 6 trips with 10 cubic yards per trip. The fixed charges were $7.75 and the operating costs for a 60-mile day $11.40. The haul to the dump averaged 6 miles.

In New York City a 5-ton truck, with specially designed 10-yard collection body, was given a trial on house-to-house collections of garbage and ashes on a 3-mile haul in the Borough of Bronx, New York. It was also given a trial on hauling garbage from relay stations in the outlying sections, where the haul was approximately 7 miles. In the collection work the truck was not so economical as the horse-drawn carts usually used, but on the longer hauls it showed considerable saving over horse-drawn wagons. For the long hauls, the truck made four round trips covering a total of 54.2 miles and hauled 27.6 tons of garbage, against about one and one-half trips made in the same length of time by a one-horse cart, hauling approximately 1½ tons (0.9 tons per load). On the house-to-house collection, the truck made five round trips, covering a distance of 32.7 miles and hauled 23.85 tons of garbage, while the cart made three round trips per day covering 18 miles, and hauled 5.4 tons. The poorer showing of the truck, on the house-to-house collections, was attributed to the time spent in loading. Four helpers were provided, but the time spent in loading represented more than one-half of the total time. The time spent in traveling to and from the dump was only one-fifth of the total. On relay work the time spent in loading was only about one-third of the total. The one-horse cart cost $4.32 per day and the cost of operating the truck was $13.70 per day.

The relative costs, however, between motor truck and horse collections include a large number of local problems, such as the location of the receptacle, character of the streets and alleys and their grades, available locations for loading stations, distance to point of final disposal, length of working day, size of wagons, and number of trips per day. Combinations of these problems may be such that in one community the cost of horse-drawn wagons may be cheaper for collection work, while in others the reverse may be true.

TABLE NO. 11.—*Collection costs.*

City.	1918		1917		1916		1915		1914	
	Ton.	Cubic yard.	Ton.	Cubic yard.	Ton.	Cubic yard.	Ton.	Cubic yard.	Ton.	Cubic yard.
GARBAGE.										
Rochester, N. Y	$2.80		$2.35							
Milwaukee, Wis	4.83		4.18		$3.07		$2.87		$2.94	
Indianapolis, Ind	2.44									
Chicago, Ill	4.21									
Buffalo, N. Y			3.92	$1.84	3.98	$1.87				
Columbus, Ohio	3.41				1.97					
Philadelphia, Pa	5.50									
St. Paul, Minn	8.70		8.30		6.10					
Boston, Mass.:										
District—										
1 [1]			4.29		3.85					
3 [1]			5.00		4.84					
5 [1]			4.82		4.58					
8,9 [1]			4.03		2.83					
10 [1]			2.49		2.54					
2 [2]			2.91		2.25					
4 [2]			2.50		1.58					
5 [2]			1.39		1.14					
6 [2]			4.77		4.25					
Hyde Park [2]			2.24		1.21					
ASHES.										
Rochester, N. Y	$1.23	$0.69	$1.13	$0.60	$0.97	$0.51	$0.95	$0.40	$0.89	$0.42
Chicago, Ill		.81								
Buffalo, N. Y			1.58	.65	1.44	.59				
Boston, Mass.:										
District—										
1 [1]			2.12		1.82					
3 [1]			3.01		2.84					
5 [1]			2.63		2.73					
8,9 [1]			2.13		2.22					
10 [1]			1.55		1.85					
2 [2]			.65		.56					
4 [2]			.88		.70					
5 [2]			.74		.69					
6 [2]			1.52		.88					
Hyde Park [2]			.85		.83					
RUBBISH.										
Rochester, N. Y	$7.86	$0.57	$6.32	$0.47	$4.88	$0.38	$4.16	$0.34	$4.65	$0.36
St. Louis, Mo				.43		.34		.42		
Buffalo, N. Y			.52	.56	.54	.60				
ASHES AND RUBBISH.										
Milwaukee, Wis		$0.79		$0.70		$0.65		$0.66		$0.70
Columbus, Ohio		.52		.43		.42		.42		
GARBAGE AND RUBBISH.										
Savannah, Ga			$2.50		$2.07		$2.26		$2.29	
PAPER.										
Boston, Mass.:										
District—										
1			$2.77		$2.47					
5			4.57		5.23					
8,9			6.74		4.70					
10			5.43		3.73					

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[1] Collected by city forces.

[2] Contract collection and disposal.

In Table No. 11 there is grouped together the cost of collection of the various classes of wastes in several cities. These data are presented to show what collections are costing some municipalities and indicate to some extent what similar collection may cost other municipalities.

In connection with collection costs it is interesting to note the cost of the annual clean-up campaign in a large city. St. Louis, Mo., for the past few years, has devoted several days each year to the removal of rubbish accumulations. In 1917 the clean-up campaign lasted 15 days. The force required for the work was as follows: 1 general superintendent, 3 district superintendents, 25 crew foremen, 7 dump foremen, 20 laborers, 15 drivers for city teams, 65 hired teams.

The total cost of the 15 days' campaign was as follows:

4 superintendents	$130.00
32 foremen	807.50
20 laborers	404.75
Cost of city teams	923.34
Cost of hired teams	2,658.38
Miscellaneous expenses	300.25
Total	5,224.22

The total loads collected amounted to 2,009, giving 12,054 cubic yards, at an average cost of $2.60 per load, or $0.433 per cubic yard. The teams averaged 2.41 loads per day.

In 1916 and 1915 the total cost of the campaigns was $4,295.60 and $2,982.40, respectively. The number of loads collected was 1,905 and 1,611, amounting to 12,556 and 8,052 cubic yards, at a cost of $0.34 and $0.42 per cubic yard.

DISPOSAL OF MUNICIPAL WASTES.

METHODS OF DISPOSAL.

GENERAL.

In general, the methods of disposal of municipal wastes may be divided into those of recovery, from which there is received some return from their disposal (in some cases an actual profit) which helps to pay for the cost of the process; and methods of destruction, where little or no profit is received, to help pay the cost of the process and in which valuable material is wasted.

In Table No. 12 there are arranged, in the order of increasing return, the various methods for the disposal of municipal wastes. On the one end there is dumping, in which method of disposal any valuable material contained in the refuse is entirely lost and no revenue received to help pay for the cost of disposal; while on the other end of the table there is reduction and feeding, which under proper management should yield some return from the sale of recoverable products that will help pay for the cost of disposal.

TABLE No. 12.—*Methods of refuse disposal in the order of greatest return, classes of waste capable of disposal by each process.*

Dumping.	Filling.	Burial.	Incineration.	Feeding.	Reduction.
Garbage. Animals. Ashes. Rubbish. Excreta. Street sweepings.	Garbage. Ashes. Rubbish. Street sweepings.	Garbage. Animals. Excreta. Street sweepings.	Garbage. Animals. Ashes. Rubbish. Excreta. Street sweepings.	Garbage.	Garbage. Animals.

Of all of the wastes garbage is without a question the most valuable as it contains food material that is capable of being utilized with profit in hog feeding, or the grease that it contains may be recovered by reduction, and, having a market value, return considerable revenue on the process of disposal. The return from reduction and feeding, when the methods are carried out under efficient management, appear to be about equal and far greater than may be expected with any other method of disposal. The apparatus for reduction is expensive and complicated and the operation costly. To make reduction feasible, there should be available the garbage from a population of at least 75,000, possibly 100,000. On the other hand, for the smaller community, feeding offers approximately the same return from the garbage, with less outlay of money at the start and the process is applicable to almost any size community.

Where garbage is incinerated it has to be mixed with other combustible wastes (ashes and rubbish) or fuel has to be supplied to furnish heat to evaporate the water it contains before the organic matter will itself burn. As a result of incineration, there may be enough heat developed, not only to run the incinerating plant machinery, but to supply an outside municipal plant such as a water-pumping station or sewage-pumping plant. It is also true that most of the heat so generated is derived from the burning of the other waste rather than the garbage and the destruction of this material (garbage) represents a direct loss.

Statistics of the United States Food Administration indicate that out of 620 cities reporting methods of garbage disposal, 16 per cent are destroying garbage by burning. Included in the 16 per cent are 19 cities having a population of over 100,000 by the 1910 census. It is estimated that 600,000 tons of valuable material are being lost.

Salvaging in conjunction with incineration is suitable for rubbish only, from which a profit may be derived from the sale of such articles as paper, rags, metals, bottles, and from the sale of steam derived from the combustion of material remaining. The profit over operating expenses will not be large, however, but some return may be expected.

The burial of dead animals, garbage, and excreta may result in a small, delayed profit from the fertilizing ingredients restored to the soil. Fats and grease, however, have no value as fertilizers and may, when they exceed about 8 per cent of the material applied, render the assimilation of the fertilizer by the soil extremely difficult. When garbage is used for fertilizing purposes the grease is entirely lost. As yet no profitable method of treating excreta for the recovery of fertilizing properties has been developed, and burial or mixing with the soil and restoring fertilizing material in this manner represents the maximum return that can be expected.

Disposal by filling represents a return only in so far as low land may be benefited and increased in value by being brought to grade, where it can be used for building sites, playgrounds, or municipal parks. Low land which has been brought to grade by filling with the various wastes is not, however, suitable to be built upon for a considerable period, as the organic matter contained in it undergoes putrefaction and decay, and settling continues for a long time.

Dumping, as distinguished from filling, has been taken as the disposal of the wastes by dumping into the sea, large lakes, or rivers. By this process any value contained in the material is entirely lost. It might also be added that while there is a direct loss from the material wasted, there may be an added loss to the community so disposing of its wastes in the nature of law suits that may arise from the pollution of water supplies affected by such dumping, the damage done to bathing beaches from floating material carried onto them by the action of the tides and winds, or the obstruction of naviagble waters from the formation of deposits. Streams into which wastes are dumped will be devoid of fish life, because the organic matter of the waste will kill out the fish food, if not the fishes themselves.

DUMPING.

By dumping is meant the disposal of waste into large bodies of water. This method is applicable to all classes of wastes. In theory the principle is to have a body of water sufficiently large to dilute soluble material, allow for settling of the heavier particles, and provide a sufficient surface so that floating material will be scattered and not noticeable. The method has been practiced by several of the seaboard cities, but the cost of towing makes the method too expensive for any but the largest communities. This method is, however, being abandoned, because the tidal currents and wind have brought the material back to the shores and caused considerable nuisance. The cleanest material has a tendency to sink, while the foulest remains on the surface, to be carried about by the wind and current. Dumping into lakes has resulted in the same conditions as where disposal has been by dumping at sea. Cities situated along the Mississippi River used this means as a method of disposal until stopped by the Government. Nuisances have invariably been created on the rivers below the point of dumping and law suits have resulted from pollution of the water or the obstruction of the channels. Dumping of such wastes into streams will either kill fish life directly or so deplete their food supply that in a short time they will disappear. This method of disposal has recently been stopped by the United States Government on interstate streams and is not recommended as a means of disposal.

FILLING.

By filling is meant the deposition of waste on land without further treatment, except perhaps for the burning of combustible material that may be mixed with it and leveling off the surface of the dumping ground. Low areas that will be improved by filling and being brought to grade are usually selected for disposal by filling.

Garbage, highly organic in composition, can not by itself be disposed of by using for fills. Putrefaction takes place, extremely objectionable odors are given off, the place becomes a breeding ground for flies, the source of supply for the community. Small animals, such as rats, dogs, and cats, are attracted to it and very shortly it also becomes the feeding ground for large and small birds. The fill built up from garbage, unmixed with other waste, can not be used for a long time, if ever, for building sites, parks, or playgrounds.

Ashes may be disposed of for filling. They make excellent fills along water fronts, in the grading of streets, and for building sites. The chief objection to the places where filling is done with ashes is from the fine dust contained in them which is blown about during times of dumping from the surface of the fill.

Rubbish can be disposed of for filling, but is liable to give rise to disagreeable conditions unless care is taken in the proper placing at the point of disposal. This class of material contains considerable combustible material and dumps are liable to take fire and burn or smolder for a long time, giving off objectionable odors. If separation of wastes is not efficient, receptacles containing waste food material may be included with the rubbish and objectionable conditions result from its decomposition. The wood, paper, and other decayable material, if grouped in the fills, will cause settling for a long time. Paper and other light or fine particles are liable to be blown about. Where fills are being made they should be carefully supervised and a caretaker should see to the proper placing of the material. The paper and combustible matter should be burned on the surface of the fill, the lighter material placed at the bottom, the heavier at the surface, and finally the surface should be finished off with ashes, street sweepings, or excavated earth. When settling takes place these spots should be brought back again to grade.

In some instances the privilege of sorting over rubbish at the point of disposal is given in return for supervision over the filling. In other communities a considerable sum is received in exchange for the privilege of sorting the rubbish and selling that which has a market value, the money received being spent to hire labor for the proper maintenance of the fills. The cost of disposal by this method is not high, because short hauls can be obtained by the proper selection of areas to be filled, and the proper placing of the materials at the disposal point under proper supervision should not add excessively to the cost.

Street sweepings, containing about 20 per cent of organic matter, create no nuisance from putrefaction when placed in fills. The finer particles may, however, be blown about, causing disagreeable conditions in the neighborhood. Fills made from street sweepings are liable to settle for a considerable period.

Stable manure is practically all organic matter and has considerable value as a fertilizer and is readily disposed of for that purpose. It is not suited for fills, as the land made could not be used for a long time and the deposition of this class of material near the city might give rise to nuisance from the production of flies.

Excreta, extremely high in organic matter, and readily decomposable, creating very objectionable and serious conditions, can not be used under any circumstances as a fill. Excreta form an ideal fly-breeding material which, combined with the pathogenic bacteria which it may contain, form an excellent combination for the spread of disease. Even if a fill of such material was allowable near a community, a long time would be required for it to dry and it is doubtful if it could ever be used to build upon or be used for park or playground areas.

A modified form of filling, called the sanitary fill, whereby mixtures of garbage, ashes, street sweepings, or rubbish may be used with success, has been developed, but careful supervision over such fills must be maintained. The method consists in spreading thin layers of garbage, about 12 inches in depth, and covering with from 18 to 24 inches of ashes, street sweepings, or rubbish. In this manner fills may be built up to a considerable depth, but constant settling will take place. As an emergency method of disposal in 1913, the city of Chicago, Ill., used the sanitary fill as a means of disposal. The garbage at Chicago, was, however, first soaked for a period of 24 hours in a solution containing one-half per cent sulphuric and hydrochloric acids, to delay putrefaction. Alternate layers of garbage and ashes were then built up to a height of 25 feet, which later settled to a depth of about 16 feet. No nuisance has as yet been created by this particular fill. This method of disposal is expensive because of the necessity of handling the material and placing on the fill.

The condition of the dumping points where fills are being made and their potential ability to create nuisances and cause objectionable conditions, depends almost entirely upon the amount of supervision that is exercised over them. The objectionable conditions arising from the blowing about of papers can be helped by fencing in the area or by collecting the paper and other combustible material and burning them under proper supervision. Fences, in addition to prevention of the blowing about of material, have the added advantage of preventing the exposure of conditions about the dump, with the psychological effect that what is not seen does not create a nuisance. If paper, wood, and other materials, which decay with time, are broken up and scattered, so that there are no large masses in the mixture, or if burned, the liability from settling is very much reduced.

To summarize, fills can not be made with garbage or excreta. Garbage mixed with ashes and rubbish can be used for fills in the smaller communities, but in the larger places the area required will be extensive and the method costly because these areas will undoubtedly be located at a considerable distance from the point where collections are made. Ashes and street sweepings make excellent fills, are not considered insanitary, and the land does not settle as with a mixture containing rubbish. Where separation is practiced, the ashes can be used advantageously for fills, but some other method of disposal will have to be provided for the other wastes.

BURIAL.

Disposal by burial is applicable to garbage, dead animals, excreta, and possibly to street sweepings, if they contain a high percentage of stable manure.

In the disposal of dead animals the procedure consists in digging an excavation sufficient in size to take the body and covering with a portion of the excavated earth, sufficient in depth to prevent animals or birds gaining access to it.

For the disposal of garbage and excreta, two methods are employed, (1) scattering the material in thin layers on the surface of the disposal area and plowing under, and (2) making a continuous trench, of varying depth and width, in which the material is deposited and covered with the soil excavated from a parallel trench. For the disposal of wastes of this class the latter method would seem to be the more satisfactory, as less surface is liable to be left exposed for flies, animals, and birds to have access to. Whichever method is used, the material should be entirely covered with earth as soon as possible after it has reached the disposal ground. Uncovered waste high in organic matter which will rapidly decompose will give off extremely offensive odors and will be the cause of complaint from any houses in the neighborhood. Uncovered waste is also conducive to the breeding of flies, and animals will also be attracted to the area.

It is to be expected that disposal of material such as excreta and possibly garbage by burial will result in the production of some flies. Many eggs of the fly will have been deposited in the material before collection and will be buried with it. Some of these will develop into the maggot, migrate out into the soil to pupate, hatch out and come to the surface of the ground. At times during the fly-breeding season the surface of the disposal area may have on it numbers of newly hatched flies whose wings have not sufficiently unfolded and dried to be able to fly. At these times birds will be attracted to the area in considerable numbers.

In selecting a disposal area for burial purposes, consideration should be given to the surface formation, in order that surface water after rains will drain away as soon as possible. The soil should be light and porous to facilitate the drainage of the water that passes through the soil, to make excavation easy for the trenching or plowing, and to admit as much air as possible to the buried material so that rapid oxidation will take place. The ground water should be well below the surface.

In freezing climates, the work of trenching or plowing will be increased by the freezing of the upper surface of the ground in winter. It may, in such cases, be necessary to prepare trenches before cold weather sets in, sufficient in capacity, to care for the material during the freezing period.

The city of Columbus, Ohio, employed burial as a means of disposal from 1906 to 1910. A tract of land 77 acres in area was purchased and all of the garbage, excreta and dead animals were disposed of by this method. Trenches 2 feet in depth and averaging 7 feet in width were dug and the material deposited in them and covered with from 18 to 24 inches of loose soil. Approximately 15 acres per year were required to dispose of the entire wastes. In 1908 there was collected from a population of 170,000 about 13,000 tons of garbage and in 1910 from a population of 176,000 a total of 16,500 tons. From these figures, one acre of land received 900 tons of garbage in 1908 and 1,100 tons in 1910, which gives an acre of land as the area necessary for the disposal of the wastes from approximately 11,500 people.

After the material was buried, putrefaction proceeded very slowly, the mass finally occupying a layer one fifth to one third the original thickness. Examination of the trenches, after varying periods of burial, showed that in 20 months it was still decomposing, produced a foul odor and the character was more or less distinguishable. After 30 months, the material was innocuous, resembling humus matter; it had a slight musty odor with the character very faintly distinguishable.

Street sweepings are very seldom disposed of by trenching. The material contains a low percentage of organic matter and does not decompose and cause objectionable odors, neither is the fly problem a serious one. This waste can be spread on the surface of the ground and plowed under, or it may be used for covering the trenches containing the garbage or excreta. This lighter material possesses some advantages as a cover where excreta is very liquid in consistency. The heavier soil, used as a covering, is liable to sink in the material, leaving the excreta exposed, while the lighter street sweepings float on the surface and form a cover.

Excreta, when disposed of by burial, are best deposited in trenches or furrows run with a plough, and should be immediately covered as soon as deposited. A furrow about 8 inches in depth may be run with the plough, the excreta deposited in it in a layer 2 to 3 inches in depth and the soil from a parallel furrow turned over it. Spots left uncovered should be finished by hand with a shovel or hoe. The covering material should be at least 3 inches in depth and preferably more if possible. By this method it is claimed that about 3,000 bushels (28,000 gallons) can be disposed of on an acre of land. On a basis of 28,000 gallons per acre and assuming the average quantity of excreta as 3.5 gallons per family of 5 per week, an acre of land would dispose of the excreta from a population of 770 for a year.

Excreta contains some fertilizing value and poor land is improved by its addition. At least 12 months should elapse before it is placed under cultivation.

The disposal of garbage by burial requires primary separation and other methods of disposal must be provided for the ashes and rubbish. For smaller communities the method appears to be better adapted, than for the larger ones where the area required would be large and the haul to it necessarily long.

INCINERATION.

As the word implies, incineration is the destruction of waste material by fire. By this process garbage, ashes, rubbish, street sweepings, dead animals, stable manure, and excreta may be disposed of, but the process is more often limited to the destruction of garbage, rubbish, and dead animals; in some cases to ashes and very much less often to excreta, stable manure, and street sweepings.

From a sanitary standpoint, incineration is a most acceptable process. If carefully carried out in properly designed and constructed furnaces, in which the temperatures are sufficiently high to decompose the gases given off, the process can be conducted without objectionable conditions arising. No liquid or solid wastes containing substances liable to decompose and cause nuisances are produced which have to be disposed of.

In a well-operated plant, there will remain ash or clinker, containing no organic matter, which theoretically has some value for fills or for constructing roads. During incineration, heat is developed, which may be utilized, with the proper installation of boiler equipment, to generate steam to operate machinery around the plant and in some instances generate enough additional, to supply an outside source. During incineration, gases are given off from the burning mass. In well-operated plants, the temperature of these gases will be raised sufficiently to insure their complete combustion and they can be released through the stack without fear of creating nuisances in the vicinity. In order to insure combustion of the objectionable gases, incinerator plants are provided with a gas combustion chamber, in which the gases are subjected to heat from a second fire, or they may be returned and forced through a portion of the main fire to completely decompose them. Theoretically the temperature of all gases given off during incineration, should be raised to a temperature of at least 1,200° F, to prevent odors in the vicinity. In plants where the temperatures are not sufficiently high, the material will be subjected to a stewing or cooking process and the vapor and gas driven off will be of a distinctly disagreeable character.

The principal studies and details of construction of incinerators, have been made in England and Germany since about 1875. In this country the first incinerator was constructed in 1885, on Governors Island, N. Y. Since that date many types of plants have been developed and installed. Many of the early plants were little more than experimental and their period of usefulness was short, due to faulty principle of design because of lack of proper knowledge of the material to be burned. Many of the earlier plants have long since been abandoned. As a result of early mistakes and continued study of proper design, there has been developed the so-called American type of incinerator successfully disposing of the refuse produced by the average American municipality.

American and foreign practice in incineration differ principally because of the character of the refuse to be treated. European practice consists in collecting garbage, ashes, and rubbish all mixed together and burning the combined household refuse. In these incinerators, more often called "destructors" in England, the refuse is burned with an artificial draft, to obtain high temperatures cremating the gases and fumes given off at a temperature sufficient to preclude nuisances. Destructor plants are almost always provided with a boiler plant, the heat of combustion furnishing steam, which in turn is utilized in the operation of forced draft fans or other machinery about the plant. In America it is more often the custom to separate the ashes from the other wastes and dispose of them separately and burn only the garbage and rubbish. It is quite generally believed in this country, where more anthracite coal is used than in Europe, and in certain sections where wood is the chief fuel used, that it is not economical to reburn such material at high temperatures to produce steam. Even though the ashes produced in this country, may at times contain as high as 30 per cent unburned coal, it also contains much fine material which tends to clog the fires of incinerators and the general opinion seems to be that the ashes can be more economically disposed of by going directly to the fills, rather than to the incinerator and then to the fills after passing through the plant.

Incineration consists in placing the material to be consumed in a suitably constructed furnace, where it is either burned because of the combustible matter contained in it, or by the heat from fuel fires, or by a combination of the two methods.

In the smaller communities, the incineration of garbage only, meets with much favor, because this class of material, being not so bulky, and being much more liable to give rise to objectionable conditions, is the only waste that is efficiently and systematically collected. Garbage containing between 80 and 90 per cent moisture, requires for its cremation, when disposed of separately, considerable amounts of fuel to evaporate the water so that the organic matter will burn. When one realizes that in efficient boiler plants it requires about 1 pound of good coal to evaporate from 8 to 12 pounds of water, and that garbage with 80 per cent moisture contains 1,600 pounds of water, it is very evident that the cost of fuel for the incineration of garbage by itself will be quite high.

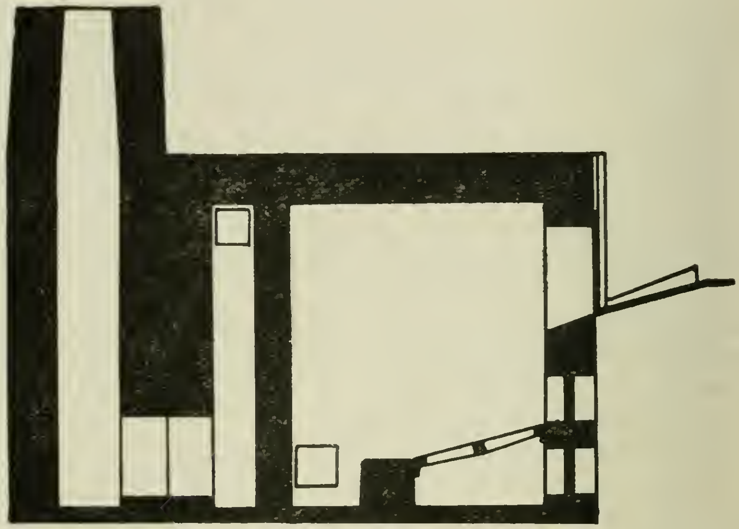
Rubbish contains a large percentage of combustible material, has a low water content, and is easily disposed of by incineration without additional fuel, even if sorting is practiced before burning.

Where garbage and rubbish are collected combined, there is usually enough combustible matter in the rubbish to evaporate the water in the garbage, so that the organic matter will burn. Starting the furnace each day to raise the temperature sufficiently to start proper combustion, will require fuel other than that contained in the refuse.

Several types of plants for the incineration of refuse have been developed, many of the construction features being patented, all accomplishing the same end, but differing in construction details and operating methods, depending upon the character of the material to be burned.

Venable (Garbage Crematories in America, 1906), divides incinerators into the following five groups:

1. Incinerators in which refuse is burned without any preliminary drying.
2. Incinerators in which refuse is burned on a grate, with but little preliminary drying on an adjoining grate.



Redrawn from Venable
Garbage Crematories in America.

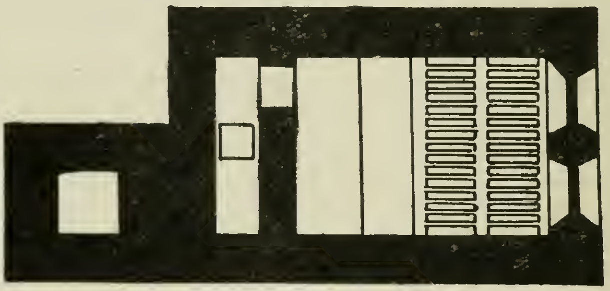
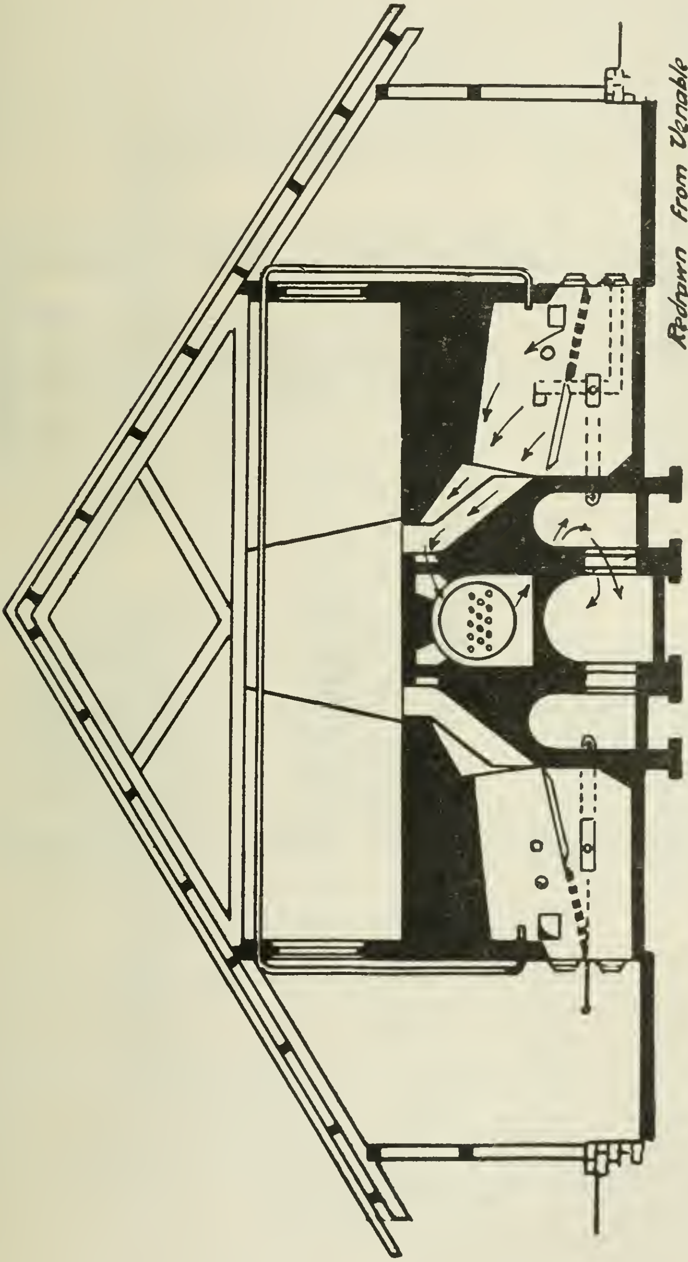


DIAGRAM NO. 6.—Hall rubbish incinerator.

3. Incinerators in which garbage is burned on a grate, by subjecting it to intense heat from fuel fires on other grates.
4. Incinerators in which garbage is first extensively dried on a grate and then stoked to another grate to be burned as fuel.
5. Incinerators in which gases of combustion from burning garbage in one cell are passed through other cells, to dry garbage in them.

Class 1 furnaces are suitable for burning rubbish or other combustible wastes only. The essential features are a large grate area and combustion chamber. No forced draft is provided in this type of plant. Wet wastes cook rather than burn and the temperatures are too low to insure complete decomposition of the gases. This type of incinerator is shown in Diagram No. 6.



Redrawn from Venable Garbage Crematories in America

DIAGRAM No. 7.—Thackeray incinerator.

Class 2, into which falls the so-called English destructor or crematory, is suitable for the disposal of all classes of wastes, including ashes. These plants have forced draft and may or may not be provided with auxiliary fires for consuming the gases of combustion. In connection with plants of this type, a boiler is usually installed to furnish power for operating fans for forced draft. Destructors are not suitable for burning garbage unless mixed with a large proportion of other wastes. A furnace of this type is shown in Diagram No. 7.

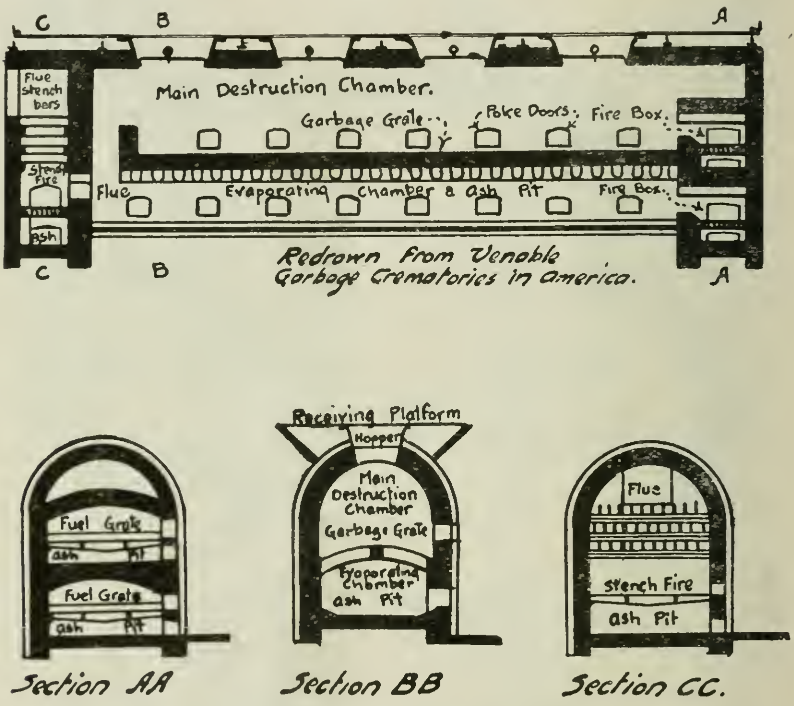
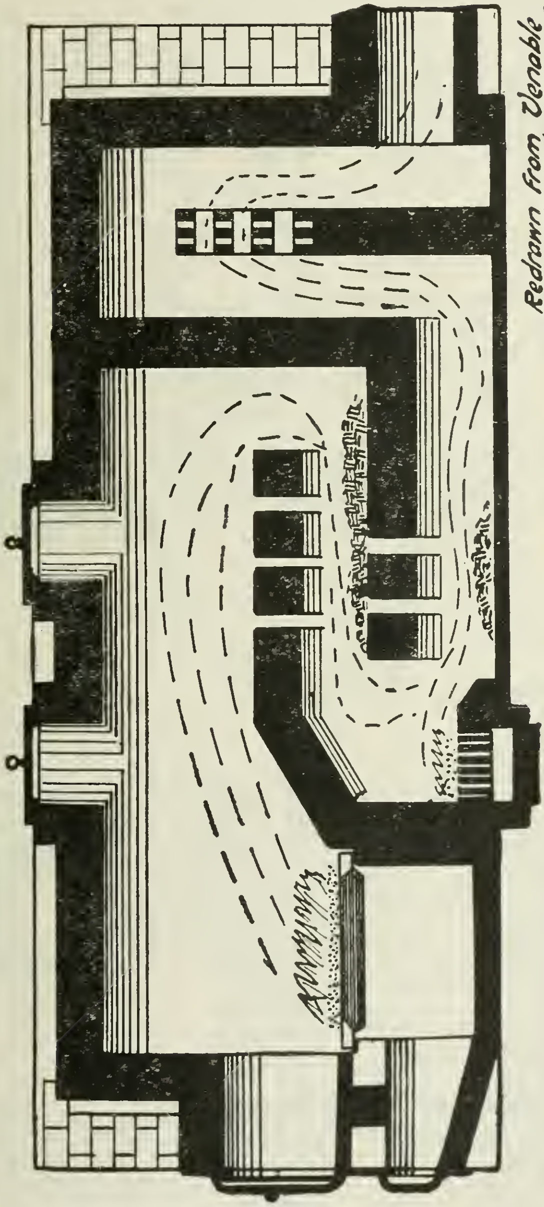


DIAGRAM No. 8.— Dixon garbage crematory.

Class 3 includes the American type, so called because of the number of installations in this country and because it seems to be specially suited for the incineration of garbage, rather than mixed wastes, as in Europe. Essential construction details consist in a large grate area or a rack, upon which the garbage is dumped and incinerated by fuel fires on another grate beneath it. A second fire, called a stench fire, through which the gases pass on their way to the stack, serves to insure their complete combustion. Plants of this general type are illustrated in diagrams No. 8 and 9.



Redrawn from Venable
Garbage Crematories in America.

DIAGRAM No. 9.—Boulger crematory.

Class 4 combines, or attempts to combine, the principles of class 3 and those of classes 1 and 2, by making burning garbage produce heat to dry other garbage so that it in turn can be burned. A plant of this type is illustrated in diagram No. 10. The Decarie incinerator shows a type of plant with water-cooled grates and steel, water-jacketed cell acting as a low-pressure boiler, which furnishes steam to operate the forced and induced draft machinery.

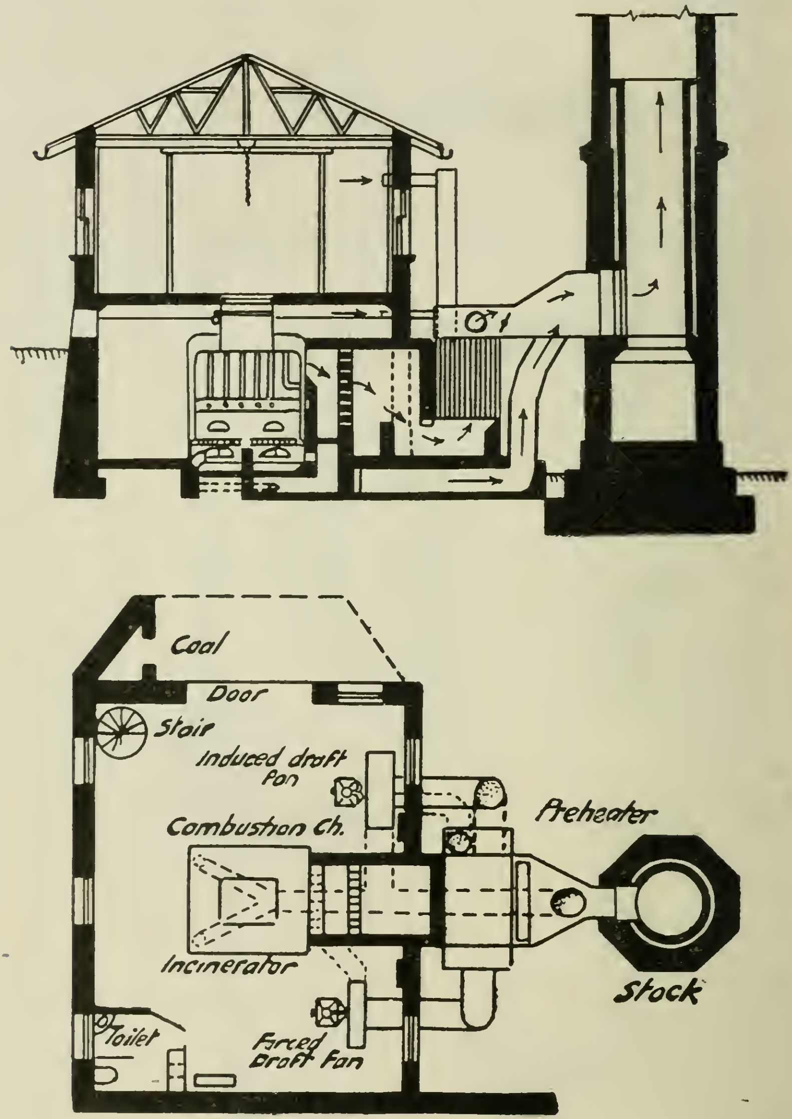


Diagram No. 10.—Decarie incinerator.

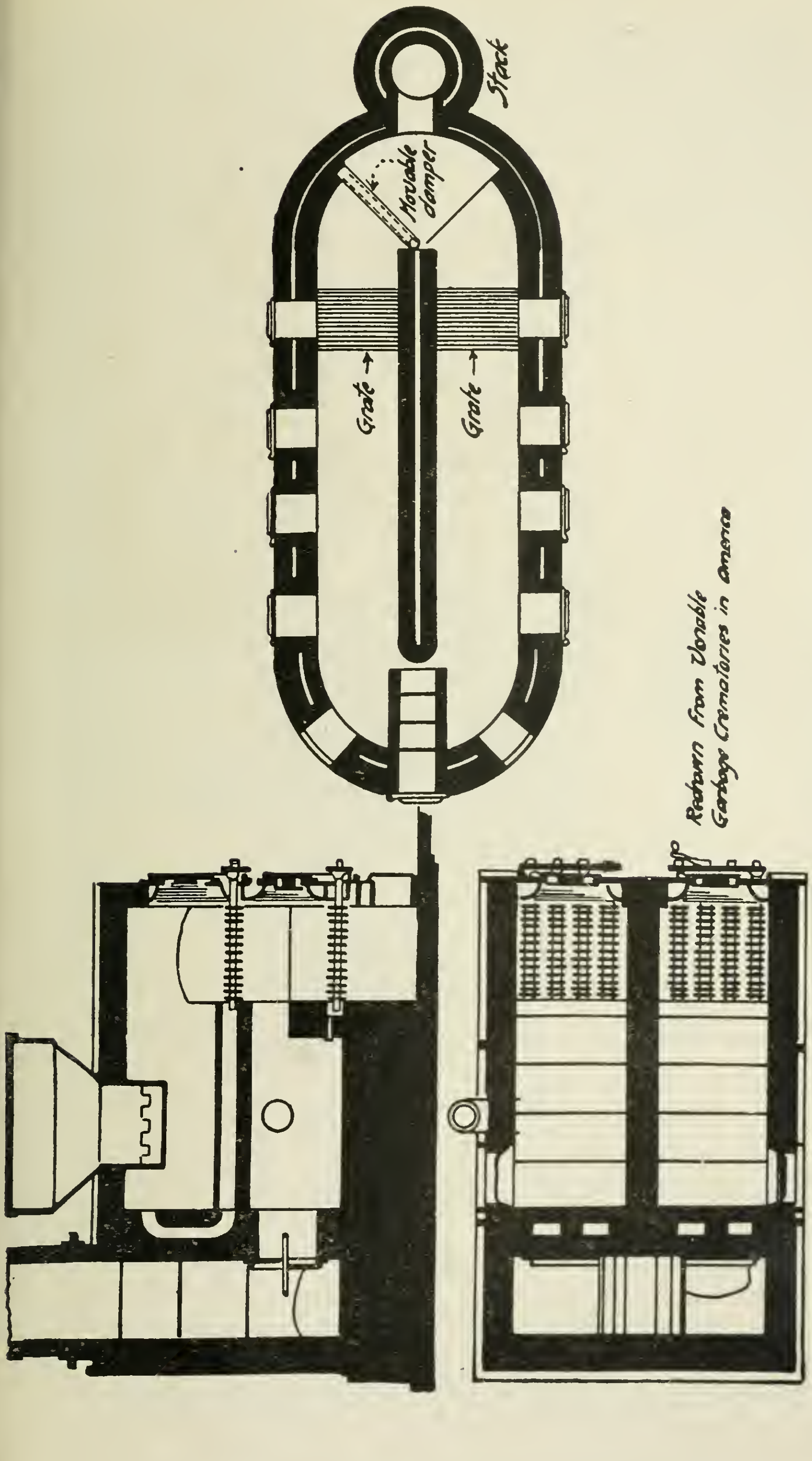


DIAGRAM No. 11.—Smith garbage furnace. Walker garbage crematory.

Class 5. This type of plant is so constructed that the path of the fires can be changed by dampers, between two or more grates and the stack, in order that the heat from one of the fires may be utilized to dry and prepare for burning the wet garbage on another grate. Plants of this type are shown on Diagram No. 11.

Incinerator plants are usually of brick construction, the walls and top of the furnace being lined with fire brick to withstand the high temperatures. The grates may be made in the form of brick arches, constructed of iron, or in the form of hollow pipes through which air or water may be circulated to keep the temperatures as low as possible. Diagram No. 12 shows the water-cooled type of grate in one of the modern incinerator furnaces.

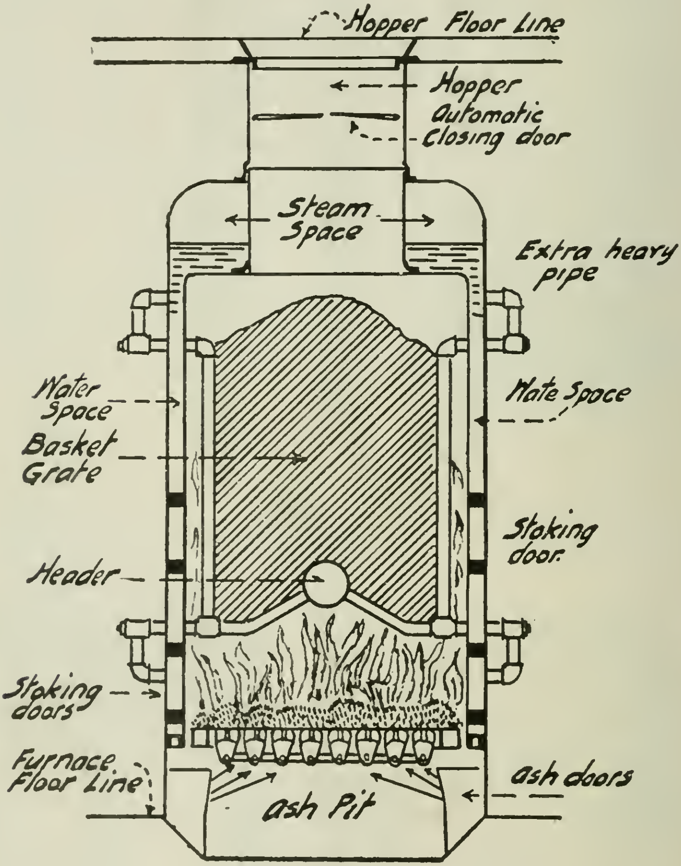


Diagram No. 12.—Decarie water-cooled grate.

The high temperatures maintained in furnaces to insure complete combustion both of the material on the grates and that driven off as gas, combined with the fact that wet, and perhaps in winter, frozen material may be constantly added, brings unusual strains upon the structure, and makes the design of durable grates and chambers a difficult problem. These conditions tend to make the cost of maintenance rather high. Maintenance and depreciation charges are rather high in all incinerator plants. They will be governed to a large extent by the character of the workmanship and the quality of the materials used in the construction, as well as upon the design. A well-designed plant poorly constructed will not last over a year, while the same plant properly constructed may last 10 years, with occasional replacement of worn parts.

The firing of incinerators requires considerable expert skill on the part of the furnaceman operating the plant. The material usually arrives at the plant as a wet, soggy mass, and is dumped in wagon loads, and unless care is taken the fires may be smothered. The material should be spread in thin layers, in order that the entire grate area may be effective. The fires should be carefully stoked, that combustion will be complete and no organic matter will be left in the ash or clinker. During stoking, care should be taken that the temperatures of the fire boxes are not lowered by excess of cool air so that combustion is retarded.

The English type of plant, which requires considerable amounts of fuel to start combustion of the wastes, is best operated continuously throughout the 24 hours. This may necessitate the storage of refuse about the plant during the day when collections are being made, to provide for night operation. The American type of plant can be operated in one shift of from 8 to 10 hours.

TABLE No. 13.—*Refuse incinerating plants and their operation.*

(Compiled by H. J. Harder, city engineer, Paterson, N. J., Sept. 23, 1918.)

City.	Population.	Name or design of disposal plant.	Kind of disposal plant.	Number of furnaces.	Size of furnaces.	When was plant built?	What was the original cost?	Does plant operate satisfactorily?	Are there any objectionable odors?
Virginia, Minn.	18,000	Decarie	Decarie			1909	$25,000	Yes	No.
Duluth, Minn.	100,000	do	Incinerator	2		1905		No	No.
Portland, Oreg.	311,351	Fred P. Smith	do	8	8 by 14 feet, 6 inches by 15 feet.	1910	99,900	Yes	No.
Chicago Heights, Ill.	25,000	Heenan & Froude	do			1911	14,000	Yes	No.
Milwaukee, Wis.	460,000	McGuire	Continuous grate destructors			1910	212,000	Yes	No.
South Bend, Ind.	70,000	Dixon	Crematory			1906		Small	No.
Oil City, Pa.	21,000	Davis	Incinerator	1	11 by 20 feet	1902	8,500	No	Yes.
Scranton, Pa.	165,000	Lewis & Kitchen furnaces	do	4	18 by 18 feet	1910	25,000	Yes	No.
Huntington, Ind.	15,000	Smith	do	2	8 feet	1912	3,500	Yes	No.
Paterson, N. J.	125,000	Heenan	Destructor	4	20 feet 6 inches by 6 by 6 feet	1912	79,000	Yes	No.
Easton, Pa.	30,000	Morse-Boulger	Incinerator	2		1911	14,000	Yes	No.
Allentown, Pa.	70,000	Dixon	Crematory	2		1902	15,000	No	Yes.
Marion, Ohio	30,000	Walker	Incinerator	1	108 square feet	1905	15,000	Yes	No.
North Braddock, Pa.	20,000	Decarie	Natural draft, 125-foot stack	1	8 by 8 feet by 10 feet high	1912	28,000	Yes	No.
Trenton, N. J.	130,000	Davis	Incinerator	4	9 by 9 by 8 feet high	1901	35,148	Yes	No.
Lancaster, Pa.	50,000	do	do	3		1902		Yes	Some.
Covington, Ky.	56,000	Dixon	Crematory	1	5 by 8 by 35 feet	1898		Yes	No.
Berkeley, Calif.	70,000	Sterling	High temperature, top feed	3		1913	60,000	Yes	No.
San Francisco, Calif.	550,000	Thackeray	Destructor	32		1897		No	Yes.
Richmond, Va.	150,000	Boulger[1]	Crematory[1]			1909	10,000		
		Decarie[2]	Water-jacket plant[2]			1910	40,000		
Petersburg, Va.	45,000	do	Incinerator	1		1913	25,000	Yes	Yes.
Cairo, Ill.	15,000	McGuire	do	2		1915	5,540	Yes	No.
Norfolk, Va.	95,000	Nye odorless	do	4	14 by 14 feet	1917	14,000	Yes	No.
Greensboro, N. C.	20,000	do		2	4 by 8 feet	1915	3,500	Yes	No.
Charlotte, N. C.	50,000		Incinerator	4	20 by 30 feet	1914	22,000	Yes	No.
Wilmington, N. C.	32,000	Decarie	do	1	10 by 10 by 14 feet	1913	35,000	Yes	No.
Pasadena, Calif.	46,000	Smith	do	8		1912	46,000	Fairly	No.
Santa Monica, Calif.	14,000	Decarie	do	2		1908			No.
Montgomery, Ala.	40,000			4		1911	1,300	Yes	No.
Savannah, Ga.	80,000	Heenan & Froude	High temperature incinerator	4	20 feet square	1913	126,000	Yes	No.
Pensacola, Fla.	31,945	Nye odorless	Crematory	1	15 by 18 feet	1913	3,500	Yes	No.
Moose Jaw, Canada	20,500	Heenan & Froude	Hopper-fed forced draft	3	6 feet long, V shape; 3 inches at top.	1911	45,900	Yes	No.
Vancouver, Canada	102,550	Fred Smith	Destructor, top feed	8	7 by 7 by 12 feet	1911	51,000	Fairly	No.
Ottawa, Canada	110,000	Heenan & Froude	Hopper feed, forced draft	3	9 feet 3 inches by 2 feet	1912	35,000	Yes	Yes.
Montreal, Canada	590,000	Thackeray	Incinerator	12	12 by 6 feet	1894	41,000	Yes	No.
London, Canada	58,600	Heenan & Froude	High temperature, including top feed.	3	Trough	1913	39,500	Yes	No.
Windsor, Canada	28,000	Canadian Incinerator Co.	Incinerator, forced draft	5		1917	23,000	Yes	At times.

City.	Population.	Nature of refuse disposed of.	Is refuse separated?	Is fuel needed in addition to garbage and refuse?	Fuel.		Capacity of plant, 24 hours.	Number of hours operated per day.
					Amount per month.	Kind.		
							Tons.	
Virginia, Minn.	18,000	All waste material except cans, glass, manure.	Yes	Yes	5 loads, 4 to 6 tons	Slabs, coal	25	8
Duluth, Minn.	100,000	Mixed garbage	No	No			50	10
Portland, Oreg.	311,351	Garbage and refuse	Yes	No			150	24
Chicago Heights, Ill.	25,000	Garbage and rubbish	No	Yes	2 tons per week	Coal	10 to 12	(1)
Milwaukee, Wis.	460,000	Garbage, mixed refuse, ashes	No	Ashes and coke.	65 per cent 25 per cent 6 per cent	Garbage Ashes Refuse	300	(2)
South Bend, Ind.	70,000	Household garbage	No	Yes				
Oil City, Pa.	21,000	Mixed refuse	No	Yes	About 200 pounds coal per ton refuse.		24	(3)
Scranton, Pa.	165,000	Garbage, refuse, waste	No	Yes	2 tons day buckwheat coal		100	8
Huntington, Ind.	15,000	Garbage, animals, waste	No	Yes	11.25 tons	Coal	44	8 to 10
Paterson, N. J.	125,000	Garbage and refuse	No	No			60	16
Easton, Pa.	30,000	Garbage and rubbish	No	Yes	$177.37 monthly	Fuel	35	10 to 24
Allentown, Pa.	70,000	Garbage	No	Yes	$133 monthly	Mine-gas coal	25	12
Marion, Ohio	30,000	Mixed	No	Yes	3,000 feet per ton	Gas	10	8
North Braddock, Pa.	20,000	Garbage and animals	No	Yes	1 bushel per ton	Coal	20	8
Trenton, N. J.	130,000	Garbage and refuse that will burn	No	Yes	16.5 tons	Bituminous coal	65 to 70	(4)
Lancaster, Pa.	50,000	Garbage	No	Yes			50	
Covington, Ky.	56,000	Garbage and butcher's offal	Yes	Yes	$250 monthly	Gas	30	20
Berkeley, Calif.	70,000	Mixed	Cans removed.	No	2 cubic yards per day	Sawdust	48	7.5
San Francisco, Calif.	550,000	General city refuse	No	Yes	Small quantity	Scrap wood	600	20 to 22
Richmond, Va.	150,000	Vegetable matter	No	Yes			50 each	24 and 9
Petersburg, Va.	45,000	Garbage and refuse	No	No			25	12
Cairo, Ill.	15,000	Garbage and dead animals		Yes		Coal	24	12
Norfolk, Va.	95,000	Garbage and refuse	Yes	No			60 each unit.	9
Greensboro, N. C.	20,000	Paper, etc.	No	No			8 to 10	10
Charlotte, N. C.	50,000	Garbage, trash, animals, etc.	No	No			60	12
Wilmington, N. C.	32,000	do	No	Yes	4 cords per month ¼ ton per month	Wood Coal	50	10
Pasadena, Calif.	46,000	Garbage and refuse	Yes	No			80	8
Santa Monica, Calif.	14,000	Is not used for burning garbage, refuse, dead animals, etc.	Yes	Yes	Occasionally	Crude oil		8
Montgomery, Ala.	40,000	General	No	No			60	12
Savannah, Ga.	80,000	Garbage, rubbish, ashes, manure	No	No			130	24
Pensacola, Fla.	31,945	Animals, household rubbish	Yes	Yes	8 cords	Light wood	16 to 20	8

[1] 24 hours summer, 16 hours winter.

[2] 24 hours week days, 16 hours Sunday.

[3] 12 winter, 24 summer.

[4] 11 winter, 24 summer.

TABLE No. 13.—*Refuse incinerating plants and their operation*—Continued.

City.	Population.	Nature of refuse disposed of.	Is refuse separated.	Is fuel needed in addition to garbage and refuse?	Fuel.		Capacity of plant, 24 hours.	Number of hours operated per day.
					Amount per month.	Kind.		
							Tons.	
Moose Jaw, Canada	20,500	Household, trade refuse, manure	No	No			50	10
Vancouver, Canada	102,550	do	Yes	Yes			80	16
Ottawa, Canada	110,000	Garbage, ashes, paper, etc	No	Yes	To start fire only in winter	Wood	75	8
Montreal, Canada	590,000	Garbage, refuse, and rubbish	No	No			200	10
London, Canada	58,600	Garbage and refuse	From ashes.	No			50	8 to 24
Windsor, Canada	28,000	Garbage and rubbish	No	No			25+	9

City.	Population.	Average amount of refuse disposed of per day.	Number of men employed at plant.	Number of shifts worked per day.	Number of men in each shift.	Wages of men employed at plant.			Other cost per day.	Total cost per day.	Total cost includes.
						Engineers.	Furnace tenders.	Laborers.			
		Tons.									
Virginia, Minn	18,000	10 to 14	2	1	2	[1] 135.00		[1] 115.00			
Duluth, Minn	100,000	Summer, 15; winter, 8.	6	3		[1] 100.00	[1] 80.00	[1] 75.00	2.40		$5,580 per annum wages.
Portland, Oreg	311,351	July, 3.5	9 to 10	3	2 to 5	4.37	4.00	3.75	1.50	38.50	Labor and supplies.
Chicago Heights, Ill	25,000	8 to 10	2 to 3	3 and 2	1	[1] 85.00		75.00	None.		
Milwaukee, Wis	460,000	225	70	3	23	[1] 115.00	[1] 90.00	[1] 70 to 85		160.00	All operations from delivery at plant until residue is delivered at dump.
Oil City, Pa	21,000	15	Winter, 1; summer, 2	1 2	1			[1] 35.25	4.50	28.85	Wages, repairs, coal.
Scranton, Pa	165,000	80	7	1	7		70.00		Fuel.		Wages of stokers and fuel.
Huntington, Ind	15,000	8	1	1	1					12.00	Two men with teams to collect garbage; one furnace tender.
Paterson, N. J	125,000	50	8	2	3 and 4	[2] 4.25		[2] 3.50		30.50	Labor and bills.
Easton, Pa	30,000	16.5	2 to 5	1 and 2	2 and 5		[2] 3.45	[2] 2.90		55.00	Labor, fuel, supplies, and repairs.
Allentown, Pa	70,000	25	2	1	2	[1] 73.50	[1] 63.00		.28		Fuel and labor.
Marion, Ohio	30,000	4 to 5	1	1	1		[2] 3.85		2.40	6.25	Do.
North Braddock, Pa	20,000		1				[1] 100.00				
Trenton, N. J	130,000	25 65	2 to 4 6 to 8	1 2	2			[2] 3.25	.85		
Covington, Ky	56,000	30	4	2	2		[2] 3.00				

Berkeley, Calif.	70,000	22	3	1	3	[1] 140.00	[1] 115.00	....	1.43	....	Water and electric power.
San Francisco, Calif.	550,000	350 to 400	50 to 60	2	40 and 20.	....	[2] 3.50 to 4	[2] 3 to 3.50	....	(?)	
Richmond, Va.	150,000	....	3	1	3	[2] 3.30	[2] 3.02½	3.02½	....	(?)	
Petersburg, Va.	45,000	20	3	1	....	[1] 125.00	[1] 100.00	[1] 75.00	....	....	
Cairo, Ill.	15,000	12	1	....	....	....	....	[3] 17.50	....	....	
Norfolk, Va.	95,000	30	....	....	....	[2] 3.40	....	[2] 3.25	.27	....	Labor, water, lights.
Greensboro, N. C.	20,000	2	1	1	....	....	[2] 2.50	....	None.	2.50	
Charlotte, N. C.	50,000	30	1	1	....	....	....	[1] 60.00	....	2.33	Labor.
Wilmington, N. C.	32,000	30¼	4 to 5	1	....	[3] 25.00	[3] 18.00	[3] 15.00	.93	15.00	Labor, fuel, supplies, repairs.
Pasadena, Calif.	46,000	9	2	1	2	[1] 105.00	[1] 100.00	....	3.83	11.00	Salaries, electricity, water, oil, ash removal.
Santa Monica, Calif.	11,000	....	2	....	....	[1] 90.00	....	....	....	....	
Montgomery, Ala.	40,000	25	5	1	....	[1] 100.00	[2] 8.00	[2] 1.50	....	12.00	
Savannah, Ga.	80,000	75	18 to 22	3	7	[2] 4.50	[2] 2.50	[2] 2.00	....	....	
Pensacola, Fla.	31,945	8 to 10	2	1	2	....	....	[1] 75.00	....	8.00	Everything directly connected with plant.
Moose Jaw, Canada	20,500	15	3	1	3	[2] 5.50	[2] 4.50	[2] 3.75	2.50	16.25	Removal of residue and general maintenance.
Vancouver, Canada	102,550	28	8	2	4	[4] .75	[4] .50	[4] 49⅜	....	28.00	
Ottawa, Canada	110,000	35	5	1	5	[1] 100.00	[1] 280.00	[1] 288.00	2.25	17.89	
Montreal, Canada	590,000	85	23	1	23	....	[2] 2.80	[2] 2.80	3.51	67.91	Wages and maintenance.
London, Canada	58,600	25	Vary.	....	5	[2] 3.85	[2] 3.30	[2] 3.30	....	22.00	Repairs to machinery, operation, etc.
Windsor, Canada	28,000	21 to 22	2	1	2	....	....	....	1.00	7.70	

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[1] Per month.

[2] Per day.

[3] Per week.

[4] Per hour.

TABLE No. 13.—*Refuse incinerating plants and their operation*—Continued.

City.	Population.	Amount of residue.	Nature of residue.	Disposition of residue.	Value of residue.	Is steam generated?	What amount?	Is steam generated used for power, for lighting, or other purposes.
		Tons.						
Virginia, Minn.	18,000		Ashes	Filling in lowland.		Yes		To operate fan.
Duluth, Minn.	100,000			do		No.		
Portland, Oreg.	311,351	20	Clinkers, ashes, cans	Part sold for fertilizer, part used for filling.	$5 to $7	Yes	100 horsepower	Heating and operating forced-draft fans.
Chicago Heights, Ill.	25,000	½ cu. yd	Fine ash	Dumped	None.	Yes		No.
Milwaukee, Wis.	460,000		Clinkers, ashes, cans	Land filling		Yes	Boilers, four 200-horsepower.	Yes; see report.
South Bend, Ind.	70,000							No.
Oil City, Pa.	21,000	(?)	Ashes, tins, cans	Fine ash sold for fertilizer, rest dumped.	(?)	No.		
Scranton, Pa.	165,000	(?)	Ash		Sold at 50 cents per gross ton.	No.		
Huntington, Ind.	15,000	1.5	do	Dumped	$6 per ton screened.	No.		No.
Paterson, N. J.	125,000	6	Clinkers and ash	Filling lowland		Yes		Lighting and motor power
Easton, Pa.	30,000		Clinkers	Deposited on dumps		No.		No.
Allentown, Pa.	70,000					No.		No.
Marion, Ohio	30,000		Glass, cans, ashes	Filling lowland		No.		
North Braddock, Pa.	20,000					Yes		No.
Trenton, N. J.	130,000		Cinders, cans, bottles	Dumping ground		No.		
Covington, Ky.	56,000		Cinders, tin cans	Removed to dump		No.		No.
Berkeley, Calif.	70,000	5	Clinkers, cans, metal waste	Metal waste sold, other for filling in.		Yes	100 horsepower	For cleaning purpose.
San Francisco, Calif.	550,000	100	Ashes, tin cans	For filling	(?)	No.		Not for power.
Richmond, Va.	150,000			Filling lowland	None	Yes	Enough to operate plant.	No.
Petersburg, Va.	45,000	(?)	Ash and clinkers	do	None	Yes		No.
Cairo, Ill.	15,000							
Norfolk, Va.	95,000		Ashes, tin cans	Taken to dumps	None	No.		
Greensboro, N. C.	20,000	(?)	Ashes	Filling lowland	None	No.		
Charlotte, N. C.	50,000					No.		No.
Wilmington, N. C.	32,000	2.5	Ashes, cans, incombustibles	Filling lowland	(?)	Yes	70 pounds	To operate blower.
Pasadena, Calif.	46,000	1	Ashes	do	None	No.		
Montgomery, Ala.	40,000		Clinkers	Fueling purposes	(?)	No.		
Savannah, Ga.	80,000	32.5	Clinkers, ashes, cans	Filling lowland	4 to 6 cents per ton.	Yes	To save $8,000 to $9,000 worth of coal.	For water works pumping station.

Pensacola, Fla.	31,945	(?)	Tin cans, glass, ashes	do	(?)	No		No.
Moose Jaw, Canada	20,500	2-3	Heavy slag, clinkers, cans	Dumping ground	None	Yes	0 to 150 horsepower.	Not at present time.
Vancouver, Canada	102,550	7			None	No		
Ottawa, Canada	110,000		Clinkers	Filling lowland		Yes	125 pounds.	Operate plant.
Montreal, Canada	590,000	5,687	Ashes and clinkers	do		No		
London, Canada	58,600	(?)	Clinkers, fine ash	River bank protection	(?)	Yes	100 horsepower	Forced draft; heating hospital.
Windsor, Canada	28,000		Tins, bottles, glass, ash	Used for fill	None	No		No.

In Table No. 13, compiled by H. J. Harder, city engineer of Paterson, N. J., and published in Municipal Journal, for October 26, 1918, are shown data relative to the cost of construction and operation of incinerator plants in the United States and Canada. Of the 28 plants, for which cost of construction is given, 8 cost over $1,000 per ton capacity, 9 between $500 and $1,000, and 11 between $200 and $500.

Folwell (Municipal Engineering Practice) states the cost of incinerating plants of the American type as varying between $250 and $700 per ton capacity, depending upon locality, capacity, make, and the amount spent upon foundations and inclosing structure. For the English type of destructor the cost will vary between $750 and $1,250 per ton capacity. These estimates of cost do not include the cost of land. The Worcester Special Waste Commission states "from a calculation based on some 30 incinerators it has been found that the cost per ton daily capacity varies from $250 to $1,000, the average being between $600 and $700."

Of the 35 plants in Table No. 13 for which data are available, 28 appear to be operating satisfactorily, 4 are stated as not operating entirely satisfactorily, 2 operate fairly satisfactorily, and 1 is too small. Out of 36 plants, 29 operate without objectionable odors, 2 give off odors at times, and 5 state that odors are given off during operation. Out of 36 plants, 21 require additional fuel besides the garbage and refuse while 15 require no other fuel.

The cost of plant operation, as shown in Table No. 13, based on the cost per day (which apparently in most cases consists of labor, fuel, and minor repairs, but not interest and depreciation) and the amount of refuse incinerated varies from $0.33 to $1.92 per ton. The average figure for the 17 plants for which cost of operation is stated is $0.85 per ton. The cost of 6 plants is over $1 per ton, averaging $1.33 per ton, and for 11 plants the cost is less than $1, averaging $0.59 per ton. Folwell states the cost of operation, including 10 per cent of the cost for interest and depreciation for the American furnace, as varying between $0.45 and $2.50 per ton and for the destructor, $1.65 to $2 per ton. Venable (Garbage Crematories in America) estimates the cost of incineration, including interest, depreciation, and repairs, but not taking into consideration any steam-raising charges or credits:

Garbage, 50 cents to $2.50.
Cinders only, 20 cents or more.
Refuse only, 25 cents to $2.50.
Mixed garbage and refuse, 30 cents to $2.50.

The residue from incineration, as shown by the table, is used in most instances for filling low areas. Four of the plants sell their residue at prices varying from $0.04 to $7 per ton. In the total of

33 plants 18 do not generate steam and 14 do. Of the 14 generating steam 8 use the power to operate machinery around the plant and supply outside sources in addition.

The Savannah, Ga., plant utilizes heat for steam purposes which is used in the waterworks pumping station adjacent. The plant is of the Heenan-Froude type, 130 tons daily capacity, and was constructed in 1914 at a cost of $124,665.27, divided as follows:

Contract price	$120,000.00
Excavation and concrete foundations	2,366.90
Paving approaches	623.98
Cost of clinker walls	234.72
Pipe line and water-softener plant	785.00
Testing materials	307.14
Incidentals	347.53
Total	124,665.27

The plant consists of 2 furnaces, each having 65 tons capacity. Each unit consists of 4 cells, with separate combustion chambers, preheaters, a 200-horsepower water tube boiler and centrifugal fan. The guaranties by the contractors stated that the plant would destroy 130 tons of refuse in 24 hours without additional fuel, no obnoxious gases would escape from the stack or building, the temperature should not fall below 1,250° F., and the average temperature of 1,500° F. would be maintained in the combustion chamber. The steam generated in the boilers from and at 212° F. per pound of refuse consumed would not be less than 1.3 pounds. The number of pounds of refuse burned per hour per square foot of grate area would not be less than 68 and the cost per ton of refuse burned, based upon the schedule of wages to be paid and the force set out in the specifications would not exceed 40.4 cents.

The plant was operated five months by the contractor before it was accepted and paid for by the city, in order that its work could be observed and any weaknesses noted. Three tests were made, in order to ascertain if the plant would work up to its guaranteed capacity and whether it would fulfil the requirements of the contract. The plant did meet the requirements and was taken over by the city. The cost of operating the Savannah plant since its installation is given as follows:

Year.	Amount consumed in tons.	Total cost.	Total cost per ton.	Credits for steam.	Net cost of incineration.
1914[1]	21,614	$13,290.71	$0.62	$4,450	$0.41
1915	27,661	21,563.38	.78	4,800	.60
1916	26,422	23,212.75	.88	4,182	.72
1917	23,400	24,804.00	1.06	8,379	.70

[1] Mar. 23 to Dec. 31.

The Milwaukee incinerator burns garbage, about 70 per cent; ashes, 25 per cent; and rubbish, 5 per cent. The cost of operation during the past eight years has been as follows:

Year.	Refuse consumed.	Cost of operation.	Cost of incineration per ton.
	Tons.		
1911	50,803	$53,363	$1.05
1912	48,413	53,180	1.10
1913	53,581	61,878	1.15
1914	54,684	66,527	1.22
1915	58,043	63,117	1.09
1916	54,275	64,238	1.18
1917	46,980	72,079	1.53
1918	45,458	81,048	1.78

The power developed from incineration is utilized to operate the Milwaukee River Flushing Station. The cost above given is the actual cost of operation and no credit is given for the power produced.

For cities purchasing incinerators certain definite requirements should be stated in the specifications and provision should be made to test the plant under normal operating conditions before it is accepted by the municipality. The test should be of at least a day's duration, preferably longer. Better still, where possible, provision should be made for the builder to operate the plant for a month or longer, the city paying the operating expenses, such as labor, fuel, etc., but the city assuming no other responsibility. After the plant has been "tuned up" and put in thorough working condition an acceptance test should be made, under the direction of some competent representative of the city. During such tests weights and composition of material incinerated should be kept, amount of additional fuel noted, temperatures in the fire boxes and combustion chamber noted, and such other determinations as are commonly required in testing plants of such character.

The contract should require that the plant will consume a certain amount of refuse in a definite time, stating whether such quantities are based on a running start or cold, the amount of additional fuel necessary, the amount of labor for proper operation of the plant, the lower limit to which temperatures will fall in the combustion chamber, that no odors will be given off from the stack or from the building, and that the ash produced will be free from organic matter. Requirements such as these are not unnecessarily stringent and can be met and are met by builders of modern incinerating equipment.

FEEDING.[1]

Because of the advances made in conservation during the past three years and because of the shortage in the general food supply the disposal of garbage by any method that would assist in decreasing this shortage has been looked upon with favor.

Reduction, with its recovery of grease and fertilizer tankage, releasing an equivalent amount of edible oils and replacing the depleted agricultural fertilizers, partially fulfills these conditions, but the process is suited only to the larger communities and even these contemplating reduction have found that the installation of the necessary apparatus, with the present high prices, is extremely expensive, if not prohibitive. Newark, N. J., a city with a population of approximately 450,000, recently obtained a bid of $750,000 for a 150-ton reduction plant, exclusive of the cost of the site, and rejected it on account of the high cost. For this reason the larger cities, endeavoring to utilize their garbage and receive some return from it, have turned their attention to the feeding of hogs as a solution of the problem. For the smaller cities this method, of necessity, seems the only one by which a return can be realized.

Of the 66 cities estimated by the 1916 census as having a population of over 100,000, 20 report disposal of garbage by feeding to hogs and 200 of the cities between 10,000 and 100,000 likewise report feeding as the method of disposal.

The test of the practicability of feeding as a method of disposal is the sale of the pork produced as compared with that of the grain-fed hog. In the light of available data the following general comparison between the two classes of hogs, gained from the experience in raising and marketing both, can be made.

1. The garbage-fed hog does not make gains quite as rapidly.
2. The garbage-fed hog shows greater shrinkage in long shipments.
3. The garbage-fed hog does not dress quite as high.
4. With proper management the meat produced is equal to and can not be distinguished from, grain-fed hogs.
5. The garbage-fed hogs are constantly exposed to cholera and inoculation is indispensable.
6. Cholera in garbage-fed hogs is generally associated with secondary infection, but can be controlled by immunization.
7. Garbage-fed hogs are not peculiarly susceptible to trichinosis and tuberculosis.

In connection with the use of meat from garbage-fed hogs there seems to be a popular prejudice that they are the cause of disease and can communicate sickness. On the other hand, there appears to be no such prejudice against the use of shellfish, oysters, lobsters, crabs, or shrimp that live in polluted water and thrive on decaying organic matter.

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[1] A large part of the information contained in this section has been taken from "Garbage Utilization with particular reference to utilization by feeding," United States Food Administration, Washington, D. C., February, 1918.

Where garbage is used for feeding, certain changes are necessary in the separation and collection of the material that are not required where other methods of disposal are practiced. The garbage should be separated from tins, cans, shells, and broken glass and should be well drained of liquids before being placed in the receptacle. Water makes the cost of hauling high and it may contain, especially sink drainage, soaps and lye, rather hard on the digestive system of the animals fed.

Collection of garbage should be more frequent when disposal is by feeding, as the fresher the garbage the higher the food value. It has been suggested that in northern climates collections be made three times a week in summer and, as far as feeding qualities are concerned, once a week in winter. For southern climates collections of garbage every day are preferable in summer and three times a week in winter.

For the greatest efficiency collections should be made under the supervision of the municipality. The municipality has the necessary and proper legal machinery to enforce the garbage regulation. Collections by the municipality are desirable even where disposal is by contract.

Feeding should be under the control of the municipality, a single individual, association, or company. Where contracts are let to several feeders, there is always difficulty in proportioning the garbage among them, so that each will obtain garbage of equal food value. The quality of the garbage will change with the seasons, from day to day, and even from different districts in the same city.

The size of herd must be sufficient to care for the maximum amount of garbage, which will occur in the summer, but the increased quantity will be offset to a certain extent by a decrease in the food value.

One hundred animals, ranging from pigs to large sows, will consume a ton of garbage a day, which gives an average ration of 20 pounds per animal. With an assumed yearly production of 200 pounds of garbage, a population of 1,000 will support from 20 to 30 hogs. Tests have shown that a gain of 1 pound per day is to be expected in growing hogs, which is equivalent to 100 pounds live weight to a ton of garbage. In experiments conducted at Washington, under the direction of Mr. F. S. Besson, assistant to the engineer commissioner of the District, 200 pigs were purchased, having a shipping weight of 21,095 pounds, the receiving weight at the farm being 20,053 pounds. After 136 days' feeding the selling weight was 46,405 pounds, giving an average daily gain of 1.06 pounds per pig.

It is claimed that, with the higher prices of food products and the tendency toward conservation, the quality of the present-day garbage is not so good as formerly. On this account it is recommended that the marketable live weight of pork be assumed as 1 to 50 pounds of garbage, which ratio with careful management can be obtained and possibly lowered.

The location of the hog farm depends upon local conditions. With wagon or truck delivery, haulage should be as short as possible, say from 5 to 8 miles, and in all probability hauling costs can be reduced by collecting from the houses with horse-drawn carts, which deliver to a central loading station, from which the haul to the farm is made by motor truck. Where delivery at the farm is by railroad, additional haul of a few miles is of much less importance.

The farm should be located on well-draining soil, preferably sand or gravel, the topography such as to permit northern exposure in summer and southern exposure in winter, and there should be abundant water available for the watering of the stock.

The new feeding farm at the city of Newark, N. J., will be built for a maximum of 5,000 hogs. Each building is to be 100 feet square, with a double concrete drive and feeding floor 24 feet wide extending through the center. On each side of the drive next to the pens is a gutter ending in a grease trap and connected with the sewer. Both the feeding platforms and the pens slope slightly to this gutter. On each side of the drive are five pens, which open into a yard 20 by 50 feet for exercise. The buildings are of saw-tooth construction, with windows in the peaks and along all of the sides. The area thus provided amounts to a total of 20 square feet per pig, of which 10 square feet is yard, 7.6 square feet pen, and 2.4 square feet drive and feeding platforms.

The type of shelter provided depends upon the length of the contract and upon the climate. With short-time contracts, an expensive outlay of funds can not be expected, neither is it warranted. The most that can be expected is a place where the pigs can be kept dry and reasonably warm. Shelters should be low to prevent the piling of the animals, with its danger from suffocation and heating, conducive to pneumonia. With this form of contract, the feeding methods and equipment must of necessity be more or less primitive. Neither can the breeding of stock be undertaken with short-time contracts.

Feeding methods are dependent to a large extent upon the method of delivery of the garbage at the farm. Feeding lots are usually provided for wagon or truck delivery. These lots are about an acre in area and are provided with one or more feeding platforms built on skids which may be moved from place to place. The garbage is dumped from the wagons or the truck on to these platforms and the pigs then let into the feeding lots. After feeding the pigs are driven from the lots and bones are gathered, from which revenue is to be expected, the platforms moved to a new location, and the ground where the last feeding occurred plowed under to eliminate moisture and spilled garbage. In winter, with richer garbage, a smaller quantity will be left on the platforms to be disposed of than in summer when the garbage contains many melon rinds. This waste must be cleaned from the platforms and disposed of. The recovery of bones averages from 75 to 100 pounds per ton of garbage. The droppings from the pigs average about 6 pounds per animal per day. By changing the location of the feeding lots from time to time, crops can be grown on the fertilized areas.

With carload delivery, feeding platforms must of necessity be constructed along the tracks to eliminate handling the garbage, which is expensive. The pigs are brought to the feeding platforms after the garbage has been spread. As these platforms are stationary and the location can not be changed, as in the former method of feeding, they should be well constructed, impervious, and acid-resisting. Troughs are not favored, as they are hard to clean, soon become attacked by the acids, and do not allow spreading of the food. It is considered advisable to spread the garbage in order that the hogs may sort out to a certain extent and reject any injurious material. Successive feeding is sometimes practiced where delivery is in carload lots. The garbage is spread upon the feeding platforms and the fattening stock first turned into the lots to secure the better material. When feeding of this class of stock has taken place, a second lot of pigs is turned in to eat the next best material, and then possibly a third lot can be fed.

The feeding of frozen garbage in winter is not considered advisable but may be unavoidable. Frozen food must be thawed by body heat before digestion will take place, which represents the expenditure of a certain amount of energy that may be more cheaply supplied from an outside source. Considerable frozen garbage is being fed, but the gains in weight are smaller. Thawed garbage seems to give as good results as in the seasons when freezing does not occur.

Supplementary foods are sometimes used to finish off the stock, or may be used on Sundays when garbage is not delivered at the farm. Supplementary food is not necessary and no differences in results are noted where garbage alone is fed or where supplementary foods are used.

From a sanitary standpoint, in some sections sterilization of the garbage has been insisted upon before the garbage is fed. Sterilization of the average run of municipal garbage does not materially add in the cost of operation, as the sale of the grease recovered in the process about covers the cost of the process. Sterilization apparatus has been installed as a part of the equipment of all of the larger feeding farms, but at present very few are using it. It is claimed that the sterilization eliminates the chance that the hog has to sort out and reject the inedible and harmful material, in that these substances are incorporated in the edible material during sterilization. The losses from feeding sterilized garbage are said to be heavier and the animals do not do so well.

The cost of feeding is dependent upon local conditions to such an extent that comparisons of cost are liable to be in error, unless all of the conditions influencing such costs are available. Perhaps the item of most importance, governing the cost of operation of the farm, is the character of the supervision that is exercised over it. It has been stated that the cost of disposal, after the garbage reaches the farm, including overhead expenses, will not exceed $3 per ton. Mr. F. S. Besson, in the light of the Washington experiments, estimates the fixed charges per hog as follows:

Immunization and dipping	$2.00
Quarantine and commission merchants' risk	1.00
Freight and shipping	1.50
Medical care	.50
Total fixed charges	5.00

With garbage costing 75 cents per ton and assuming that 3 tons are consumed per pig while on the farm, the cost of feed would be $2.25 per pig. Labor is estimated at $1.50 per pig, making the total cost of disposing of 3 tons of garbage $9.75, or $3.25 per ton. These figures make no allowance for interest on the first cost of the site, on buildings or other equipment. This installation cost has, however, been estimated as $8 per pig, not including land.

Individual feeders have varying ideas as to the number of animals that should be kept in a single pen. Piling up of the animals seems to be the greatest concern of those in the feeding business. Some firmly believe that as low as 10 hogs should be kept in a pen. Records indicate that as high as 500 to 600 can be kept in a single pen without sufficient piling to cause harm. One or possibly two brood sows should be kept in a single pen. When pigs are weaned 8 to 10 should be kept to the pen until from 8 to 10 weeks old. Pigs of approximately the same size should be kept together. When they have attained a weight of from 60 to 75 pounds they can be turned into comparatively large lots.

It can be stated that the greater the number of hogs kept in a single inclosure the greater the chance for the spread of parasitic infection.

Differences of opinion exist between breeders as to the merits of purchasing stock on the market or raising the pigs from garbage-fed parents. The bulkiness of garbage as a food, when compared with grain, makes necessary a larger stomach capacity in the garbage-fed hog for equal assimilation of food. The hog brought up on garbage from infancy should adapt itself to the food and acquire the larger stomach as a result of diet. With short-time contracts breeding can not be undertaken and hogs will have to be purchased for feeding.

All breeds of hog are being successfully raised on garbage. They are usually purchased on the market, at a weight between 75 and 100 pounds, at which weight they thrive best and put on weight most rapidly.

Hogs fed on garbage are constantly exposed to cholera, and immunization against this disease is absolutely necessary. The treatment must be applied by a competent veterinarian or other person specially qualified.

As has already been stated, local conditions so affect the cost of feeding that comparisons of cost figures are confusing, unless all of the details affecting them are known. As an example of what has been accomplished at one of the oldest hog-feeding farms, under municipal control, the following figures are presented.

Worcester, Mass., with a population of about 200,000, maintains a garbage-collecting system and a hog-feeding farm under the direction of the overseers of the poor. The farm comprises about 40 acres, located 6½ miles from the center of the city. Collections are made twice weekly and the garbage hauled to the farm and fed to the hogs. The average number maintained is 2,000. The first cost of the farm has been estimated as $40,000, of which $36,000 was for buildings, platforms, fences, etc., and $4,000 for land.

The operating expenses of the hog farm for the year 1917 amounted to $14,917.91, which was divided as follows:

Labor	$5, 940. 00
Grain and bedding	1, 896. 65
Serum and virus	2, 581. 26
Repairs to buildings	1, 000. 00
Miscellaneous	3, 500. 00

The receipts from sales during the year 1917 amounted to $51,737.33, showing a net profit of $36,819.42, or about $5.65 per ton of garbage fed.

During the 24 months between December, 1916, and December, 1918, the total expenditures for collection and disposal were $162,654.51 and the receipts $95,168.75, which leaves a net cost of collection and disposal as $67,485.76 for the two-year period. The cost of collection and disposal during this period was about 17 cents per person per year and the cost per ton $4.16.

The price paid by the contractor for garbage is very commonly based on the price per pound of live killing hogs on the Chicago market, the price depending somewhat on the city, whether separation is well enforced and on the character of the population from which the garbage is received. The bidding price on garbage varies between three to eight times this market price of hogs. At Newark, N. J., the price to be paid to the city by the contractor is eight times the Chicago price. Assuming the bid to be 8 and the price of hogs to be 15 cents per pound on the hoof, garbage would cost the contractor $1.20 per ton. Using the Washington estimates of cost the total expenditure per pig would be:

Cost of feed (garbage)	$3.60
Labor	1.50
Fixed charges on hogs	5.00
Total	10.10

If the pigs gain 120 pounds and sell at 15 cents per pound, or $18, then $7.90 represents any profit, after overhead, incidentals, etc., have been deducted. Efficient management will determine to a large extent what percentage of this $7.90 is to represent profit.

REDUCTION.

Reduction is a process in which the raw material is so treated that a separation of the liquid and solid portions take place, and grease is recovered from one or both of them. The products resulting from the reduction of garbage are grease, recovered from both the liquid and solid portions, waste water, which may or may not contain putrescible organic matter in solution, gases produced in the cooking operation liberated and escaping into the air, and tankage or solid residue. Grease and tankage have a market value and can be readily disposed of. The waste water if not properly disposed of may contain substances in solution and suspension that undergo decomposition and produce a nuisance if disposed of into open sewers or small bodies of water. The gases produced in the cooking operations are very liable to create a nuisance if provision is not made for their proper combustion and destruction.

The reduction process is suited to the treatment of garbage and dead animals. Where used, other methods of disposal must be provided for the other wastes.

There are several patented processes in operation for the reduction of garbage, all more or less satisfactory in the results they accomplish.

In Diagrams No. 13 and No. 14 it has been attempted to illustrate graphically the steps in some of the various methods of reduction, showing the steps in the separations and how the grease and other substances during the operations are recovered. The index letter corresponds throughout to the steps in one system of reduction, so that wherever the same letter appears those particular operations belong to the same process. As an example, in the process (*a*) the garbage is first sorted, the foreign material removed and disposed of by sale.

The sorted garbage is then drained of the free water, which is run to storage basins, to which is added later water from the pressing operations. The drained garbage is then cooked with steam in large

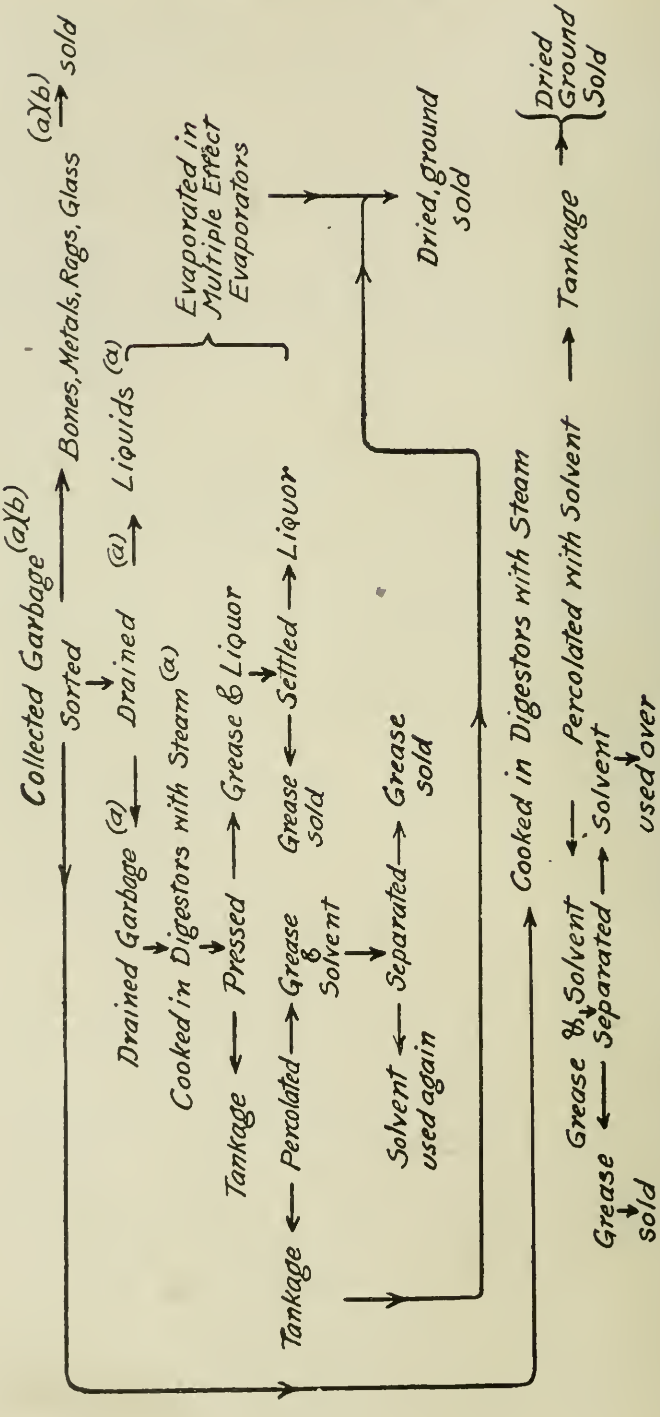

DIAGRAM No. 13.—Methods of garbage reduction.

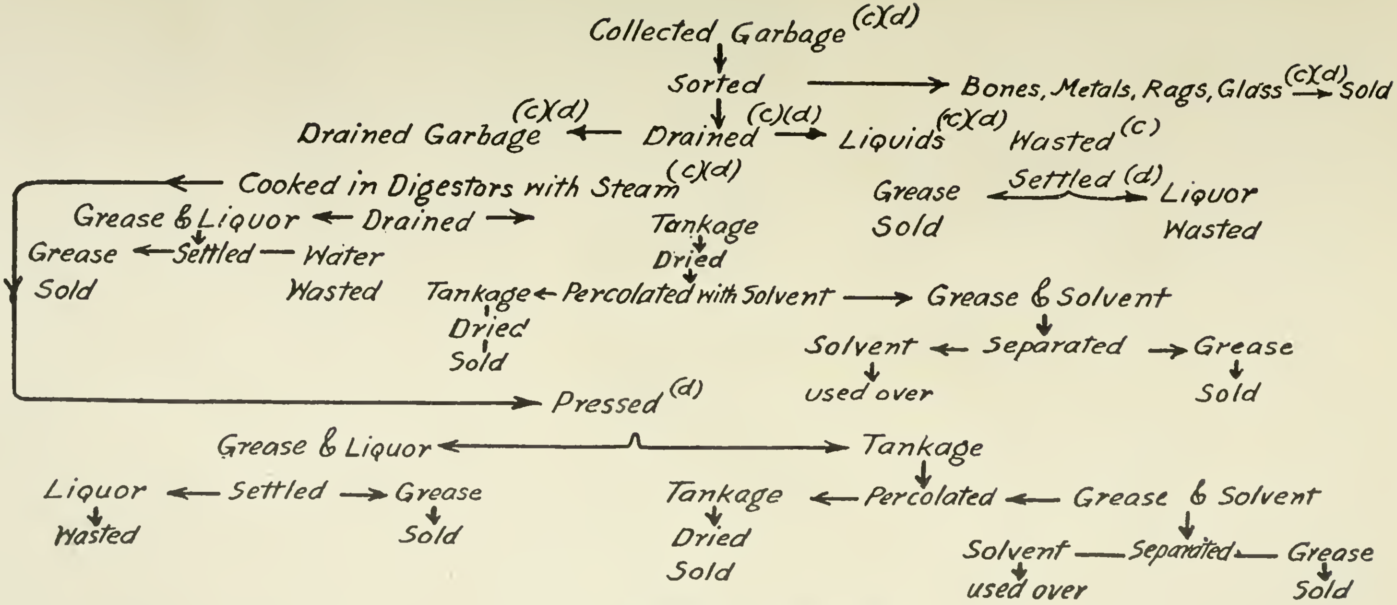

DIAGRAM NO. 14.—Methods of garbage reduction.

digestors, during which process grease is liberated. After cooking has been completed, the digestor contents are run to presses where a separation is made into water, containing grease and soluble solids and cooked garbage, which also contains grease mingled with it. The liquid portion (grease and water) is run into the storage basins that contain the water from the draining process. In these basins the grease rises to the surface, is skimmed off, and saved for further treatment and sale, while the water is run to and evaporated in multiple effect evaporators, where a thick molasseslike liquor is produced, which is later treated further. The pressed solids are placed in an extractor and naphtha forced through the mass, dissolving out the grease in the solvent. The naphtha and grease are then separated by volatilizing the naphtha, leaving the grease behind, and the naphtha is recovered by condensation and used over again in the process. The residue from the naphtha treatment is mixed with the thick molasses liquor from the evaporators and dried in rotary driers until most of the water has been driven off. This dried residue is ground, screened, and is ready for sale as a fertilizer base.

The diagram shows further from which of the processes wastes arise. In the process just described there is no liquid waste, but a dry waste in the form of dust from the final screening of the dried residue, which, however, is not objectionable. In the other processes there is a liquid waste from the draining of the wet garbage and from the water liberated after settling of the press liquor. Both of these wastes are liable to contain substances in solution and suspension that will decompose and cause objectionable conditions, unless properly cared for.

Reduction plants, unless properly designed and efficiently operated, will give off very objectionable odors during the cooking operation. It has been stated that there never was a plant in operation that did not at some time give off objectionable odors. Prior to the last 9 or 10 years most garbage reduction plants were privately owned and operated and the question of odors was a secondary consideration. In the modern plants the methods of eliminating odors have been so well established that if the desire and money are available to install the apparatus the nuisance from odors can be reduced to a minimum.

The reduction process as a method of disposal is only suitable for the larger municipalities. To be feasible there should be available the garbage from a population of at least 75,000, possibly 100,000. Reduction requires the installation of a considerable amount of complicated, patented, and expensive machinery. The depreciation of the apparatus is high because of the presence of acids in the garbage.

The operation of such a plant must be under efficient supervision at all times to insure proper and maximum recovery of the valuable ingredients and to eliminate as far as possible odors from the processes. With the present high prices the cost of installation becomes a serious consideration, even in cities where the process could be established. The cost of installation of such a plant will probably vary between $4,000 and $8,000 per ton capacity under present conditions, depending upon the location.

In 1905 the city of Cleveland, Ohio, began the operation of the first municipally owned plant in this country. In most instances private companies owned the reduction plants and contracted with the cities at prices ranging from 75 cents to $2.50 per ton for the disposal of the garbage delivered to them by the city.

Municipally operated plants are now disposing of the garbage at Akron, Cleveland, Columbus, and Dayton, Ohio; Rochester and Schenectady, N. Y.; Detroit, Mich.; Chicago, Ill., and Indianapolis, Ind.

TABLE NO. 14.—*Operation of garbage reduction plants.*

	Chicago, Ill.				
	1914	1915	1916	1917	1918
Total garbage reduced..........tons..	75,600	150,875	137,920	100,146	84,974
Garbage grease produced..........do....	....	....	....	2,013	1,599
Garbage tankage produced..........do....	....	....	....	22,680	15,780
Pounds grease per ton garbage..........	....	....	....	40.2	37.6
Pounds tankage per ton garbage..........	....	....	....	254.0	371.2
Total income..........	$96,585	$183,197	$410,512	$456,523	$572,449
Total expenditures..........	$154,684	$278,570	$432,721	$487,535	$489,570
Profit on reduction process..........	....	....	....	....	$82,879
Cost of garbage disposal..........	$58,099	$95,372	$22,209	$31,012	....
Revenue per ton of garbage..........	$1.28	$1.21	$2.98	$4.56	$6.74
Expenses per ton of garbage..........	$2.05	$1.84	$3.14	$4.87	$5.76
Profit per ton of garbage..........	....	....	....	....	$0.98
Cost of disposal per ton of garbage..........	$0.77	$0.63	$0.16	$0.31	....
Cost of collection per ton garbage..........	....	....	....	....	$4.79
Cost per ton collection and disposal..........	....	....	....	....	$3.81

	Columbus, Ohio.			Indianapolis, Ind.	Rochester, N. Y.	
	1916	1917	1918	1918	1917	1918
Total garbage reduced..........tons .	21,861.57	17,127	15,629	12,187	25,971	29,271
Garbage grease produced..........do....	672.39	388.38	338.20	....	189	158
Garbage tankage produced..........do....	2,253.02	1,754	1,603.30	....	2,621	2,685
Pounds grease per ton garbage..........	64.2	45.3	43.2	....	14.5	10.8
Pounds tankage per ton garbage..........	205.9	204.9	205.2	....	201.8	183.5
Total income..........	$88,564	$79,344	$112,288	$87,427	$28,476	$38,235
Total expenditures..........	$48,424	$71,911	$85,621	$72,530	$56,442	$74,011
Profit on reduction process..........	$40,140	$7,433	$26,667	$14,897	$27,966	$35,775
Revenue per ton of garbage..........	$4.05	$4.62	$7.18	$7.18	$1.10	$1.31
Expenses per ton of garbage..........	$2.21	$4.19	$5.47	$5.96	$2.17	$2.53
Profit per ton of garbage..........	$1.84	$0.42	$1.71	$1.22	$1.07	$1.22
Cost of collection per ton garbage..........	$2.24	$2.79	$3.63	$2.45	$2.36	$2.80
Cost per ton collection and disposal..........	$0.40	$2.37	$1.92	$1.23	$3.43	$4.02

In Table No. 14 there has been brought together data on the cost of reduction at such places as information could be obtained, also the amount of garbage treated and the yield of grease and tankage. In this table there is also shown the cost of collection and disposal, deducting any profit from the cost of collection or adding to it such cost of disposal, as the case might be.

Table No. 15 shows the production of grease and tankage, expressed in percentage of the total garbage treated.

TABLE NO. 15.—*Production of grease and tankage in per cent of the total garbage treated.*

City.	Year.	Grease.	Tankage.
		Per cent.	*Per cent.*
Chicago, Ill.	1918	1.9	18.6
Do.	1917	2.0	22.7
Columbus, Ohio	1918	2.2	10.2
Do.	1917	2.3	10.2
Do.	1916	3.1	10.3
Rochester, N. Y.	1918	.52	9.2
Do.	1917	.73	10.2

From this table it will be seen that the recoverable material in garbage amounts to from about 10 to 25 per cent of the total treated.

In Table No. 16 there is shown for three of the reduction plants, from which data are available, the total amount of grease and tankage produced, the amount of each recovered from every ton of garbage, the price received from its sale and the total value of the products recovered.

TABLE NO. 16.—*Garbage reduction: Grease and tankage production.*

City.	Year.	Total garbage produced	Total grease produced.	Grease produced per ton garbage.	Average price per pound.	Total income from grease.	Total tankage produced.	Tankage produced per ton garbage.	Average price per ton.	Total income from tankage.
		Tons.	*Pounds.*	*Pounds.*			*Tons.*	*Pounds.*		
Chicago, Ill.	1918	84,974	3,198,177	37.6	$0.104	$331,736	15,780	371	$12.28	$193,659
Do.	1917	100,146	4,023,480	40.2	.068	273,572	22,680	254	6.50	146,724
Columbus, Ohio.	1918	15,629	....	43.2	....	....	....	205	....	....
Do.	1917	17,127	776,759	45.3	.075	58,398	1,754	205	10.82	19,015
Do.	1916	21,862	1,344,789	64.2	.053	67,598	2,253	206	8.30	18,677
Rochester, N. Y.	1918	29,271	315,054	10.8	.087	27,307	2,685	184	2.68	7,204
Do.	1917	25,971	377,244	14.5	.062	22,834	2,621	202	1.66	4,361

Table No. 16 shows the result of higher prices for grease and tankage during the year 1918 and also shows the decrease in the amount of grease recovered from the garbage due to higher price of food supplies and conservation.

At Chicago, Ill., it will be noted that the year 1918 was the first that a profit has been realized on the disposal of garbage, amounting to $0.98 per ton. During the other three years shown in Table No. 14 there was an expense attached to the process of disposal which varied from $0.16 to $0.77 per ton.

At Columbus, Ohio, there has been a return on the reduction process during the three years 1916 to 1918, inclusive showing a variation from $0.42 to $1.82 per ton.

In the cost of operation of these plants no allowance is made, with the exception of the Indianapolis plant, for plant depreciation or interest on the investment. The profit from reduction is, therefore, somewhat higher than it actually should be. The reduction plant operated by the city of Indianapolis, Ind., for the seven-month period May 26 to December 31, 1918, shows an operating profit of $1.22 per ton. The Indianapolis plant was taken over by the city in May, 1918, at a cost of $175,000. During the seven months' operation under city management the operating expenses have amounted to $72,530, which includes items of $17,500 for plant depreciation and $4,703 for interest on the investment. After deducting the sum of $72,530 from the total revenue of $87,427 there remains $14,897, which represents a return of 8½ per cent on the investment.

As has already been pointed out, reduction is suitable for the disposal of garbage and dead animals. Separation is required and other methods of disposal must be found for the other wastes. The cost of installation is high because of complicated and patented machinery, on which the depreciation is rapid. The plant requires expert supervision, and because of objectionable odors that are liable to be created should be located some distance from the city, which increases the cost of collection. Cities under 75,000 population can not use this method of disposal to advantage because sufficient garbage is not available to make the process feasible.

DISPOSAL PRACTICE.

For certain classes of waste the size of the community will have no effect whatever on the method of disposal. Dead animals in the smaller community will have to be disposed of by burial. Where incinerators are in operation, disposal will be by burning, and where there is a reduction plant in the community these wastes will return some revenue by rendering the animals. Street sweepings will in most instances be disposed of for filling in low areas, in some cases may be burned in the incinerator, or may be used in fills for covering garbage. Excreta will be disposed of by burial, by dumping into existing systems of sewers, and in rare instances by burning in incinerators. Stable manure should be sold for its fertilizer value, either by the individual or by the municipality, in the few instances where such collections may be made.

The size of the community will have considerable effect on the methods to be employed in the disposal of garbage, ashes, and rubbish. As has been stated several times already, set rules for the collection and disposal of refuse in any given community can not be made. For this reason the following discussion is indicative only of what has been done and what is being done in a number of communities.

The development of collection and disposal in a growing community may result in several successive methods. The smaller community may at first make collections only of the less bulky garbage, the ashes and rubbish being left to the individual for disposal. Where land is available not far from the center of population burial may be the easiest and most economical method. A community of 5,000, assuming an average per capita annual production of 200 pounds and further assuming the maximum and minimum monthly production to be 11 and 6½ per cent, respectively, of the annual, the municipality would be called upon to dispose of from 32 to 55 tons of garbage per month. As a cubic yard of garbage weighs in the vicinity of 1,300 pounds, the daily amount of garbage to be disposed of would vary between 2 and 4 yards, requiring no very large amount of space or labor for its disposal by burial. With increasing population and corresponding increase in the amount of garbage to be disposed of larger areas of land are required at a greater distance from the center of population, and the method becomes more difficult and costly. Cities the size of Columbus, Ohio, with a population of 176,000 in 1910, and Newark, N. J., with a population of 429,000 in 1918, have, however, used burial as a temporary method, while other methods were being developed, with success.

As the community grows the disposal of the ashes and rubbish, as well as the garbage, may become a necessity. With separation the garbage may be utilized by feeding to hogs, which method is applicable to almost any community, as is indicated by Baltimore, Md., with a population of 720,000 and Newark, N. J., 450,000, and a portion of the valuable material contained in it, made to yield some return to the community. Garbage by itself may be disposed of by incineration, but in smaller places, say up to 5,000, burial or feeding will undoubtedly be more economical, as the cost of incinerators is rather high, and where garbage alone is burned considerable fuel is required. However, a time will be reached when the quantity of garbage will have increased to such an extent that it will be more economical to utilize some of the heat contained in ashes or combustible rubbish rather than to buy fuel for the incineration of the garbage. For communities over 100,000 reduction of garbage will perhaps yield some return on disposal. With separation, in the smaller community, the ashes and rubbish can probably be more economically disposed of by use in fills. In the medium-sized or large community it may prove economical to sort the rubbish, salvage and sell a portion, and burn the remainder, possibly furnishing heat to burn some of the garbage, or generate steam to operate a municipal water or sewage pumping station. Where rubbish is sorted, ashes can be disposed of in fills to advantage.

If separation is not practiced, it will probably be more economical for the smaller community to dispose of the combined refuse by deposition in fills, using possibly the so-called sanitary fill. This method is being used at Davenport, Iowa, Seattle, Wash., and New Orleans, La., and was used for a time as an emergency method in a city as large as Chicago. With mixed refuse, in combination of ashes, garbage and rubbish, or garbage and rubbish, disposal by incineration may be adopted. The lower limit of population at which incineration is economical is placed at 10,000. Several plants in selected districts in the larger communities which make the haul comparatively short may prove the most economical.

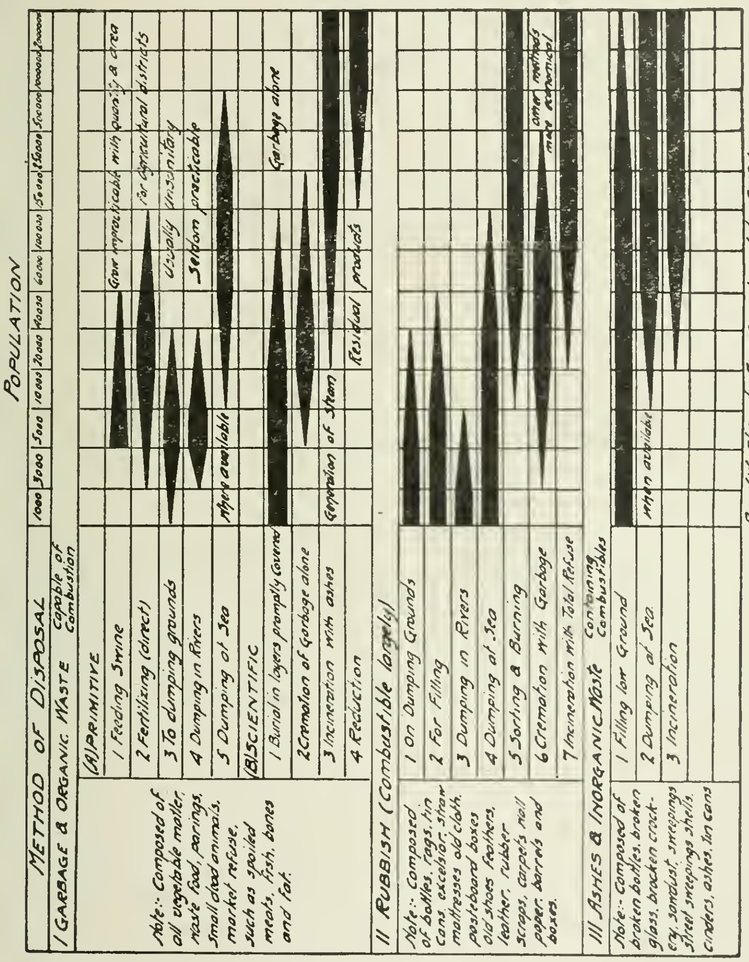

DIAGRAM NO. 15.—City waste disposal. Diagram showing economic methods according to population. Shaded areas show relative practicability of methods for any size city.

To show the general applicability of different methods of disposal to different sized communities, Diagram No. 14, compiled by J. W. Alvord, consulting engineer, is presented.

From a study of the methods of disposal in 119 communities, with various populations, Diagram No. 15 has been prepared, showing the methods of garbage disposal, the population of the community, and the grouping according to size of community and method of disposal.

From this chart it will be seen that reduction becomes applicable as a method of disposal when the population reaches about 80,000 and is suitable for places of any size above this. The smallest city shown in the chart using incineration has a population between 10,000 and 20,000. Between 20,000 and 200,000 the cities using incineration seem to be evenly grouped. Feeding appears to be favored by communities between 100,000 and 200,000, but places with populations as low as 10,000 and as high as 750,000 are using the method successfully. The remaining methods, or combination of methods of disposal, are practiced by the communities between 10,000 and 50,000.

The accompanying diagrams and discussion, while in no way conclusive as indicating the method of disposal for a given community of a definite population, may serve as a guide to direct into the proper channels of investigation those confronted with the problem of inaugurating a system of refuse collection and disposal, or those searching for more economical or sanitary methods than the existing ones afford.

A study of an existing, efficient system is essential. Too much reliance can not be placed on published facts and figures, as in municipal reports costs are not figured on the same basis and the items included in the figuring are not always stated. Quantities are not always accurate, variations occurring from season to season, and weights and yardage are not always in constant ratio.

TABLE NO. 17.—*Diagram showing size of community and method of garbage disposal.*

Population.	Incineration.	Incineration and dumping.	Incineration and feeding.	Reduction.	Reduction and feeding.	Feeding.	Dumping.	Burial.	Feeding and dumping.	Plowing.	Feeding and plowing.	Dumping and plowing.	Population.
0 to 5,000													0 to 5,000
5,000 to 10,000							X						5,000 to 10,000
10,000 to 20,000	XXX					XXX	XXX XXX XXX		XX	X			10,000 to 20,000
20,000 to 50,000	XXXX XXXX XXXX	X					XXX XXX		XX	X	XX	X	20,000 to 50,000
50,000 to 75,000	XXXX XXXX XX		X				X	X					50,000 to 75,000
75,000 to 100,000	X			X			X						75,000 to 100,000
100,000 to 200,000	XXXX XXXX XX	X		XXXX XX		XXXXX XXXXX XXX							100,000 to 200,000
200,000 to 300,000		X		XXX		XXX	X						200,000 to 300,000
300,000 to 400,000	XX			X			XXX						300,000 to 400,000
400,000 to 500,000	X	X		XXX									400,000 to 500,000
500,000 to 600,000	X			X	X	X							500,000 to 600,000
600,000 and over.				XXX XX	X								600,000 and over.

The study of disposal methods in any community should be considered an engineering problem. It too frequently happens that in small towns the study of disposal methods is placed in the hands of the city council, board of health, board of public works, or possibly a local organization, such as the Rotary Club, business men's club, or a committee of the chamber of commerce, and it also very frequently happens that there is no man connected with these organizations sufficiently trained in sanitation to form a just opinion as to what is needed. In such places, it is earnestly recommended that an engineer who has had experience in refuse disposal be employed to assist and advise the local authorities as to the best methods suited for the community in question. It is believed that the funds so invested will be returned many times over by avoiding many of the useless, unnecessary, and annoying mistakes common to refuse collection and disposal.

APPENDIX I.—MUNICIPAL POWERS AS TO GARBAGE.

By John Simpson.

(Municipal Journal and Public Works, May 31, 1919.)

The following statement of the law on the subject of the power of municipalities in regard to the disposal of garbage has frequently been approved by the courts and is in harmony with the majority of the adjudicated cases: The removal and disposal of garbage, offal, and other refuse matter is recognized as a proper subject for the exercise of the power of a municipality to pass ordinances to promote the public health, comfort, and safety. The natural scope of an ordinance on this subject is confined to discarded and rejected matter, i. e., to such as is no longer of value to the owner for ordinary purposes of domestic consumption. If the matter in question has not been rejected or abandoned as worthless, and is not offensive in any way to the public health, it does not come within the natural scope of such an ordinance. Garbage matter and refuse are regarded by the decisions as inherently of such a nature as to be either actual or potential nuisances. By reason of the different nature of the substance, it is therefore not a valid objection to an ordinance requiring disposal in a specified manner, that garbage has some value for purposes of disposal, and that the effect of the ordinance is to deprive the owner or householder of such value. That the owner suffers some loss by destruction or removal without compensation is justified by the fact that the loss is occasioned through the exercise of the police power of the State, and the loss sustained by the individual is presumed to be compensated in the common benefit secured to the public. (2 Dill., Mun. Corp., 5th ed., 678.) The reasons put forward by the courts for these rules, and their application to various circumstances, with the few contrary decisions, will be found below.

An ordinance of the city of Omaha makes it a misdemeanor for anyone not employed by the city for that purpose to remove or haul any garbage through the streets or alleys; provides for the collection of garbage by city employees; requires every householder, or occupant of any building, and the proprietor of any hotel, restaurant, cafe, and boarding house, to place all garbage in proper receptacles reasonably accessible to the garbage collector; and defines "garbage" to include "every refuse, accumulation of animal, fruit, or vegetable matter that attends the preparation, use, cooking, or the dealing in or storage of meats, fish, fowl, fruits, or vegetables."

King, the proprietor of a restaurant in the city, sold the waste from his kitchen to one Urbach, who hauled it beyond the city limits as feed for swine. They both sued to enjoin the city from enforcing the ordinance in so far as it prohibited anyone not employed by the city for that purpose from hauling garbage through its streets and alleys. The question presented was whether the enactment of the ordinance was a proper exercise of police power. The Nebraska Supreme Court, Urbach *v.* Omaha (1917), 101 Nebr., 314, answered the question in the affirmative, holding on the authority of the earlier decisions, that under the police power of the city, garbage, as defined in the ordinance, may be treated as a nuisance per se.

The plaintiffs in the Omaha case further contended that the ordinance was void because it prohibited the owner of garbage from feeding it to fowl or animals on his premises. On this point, the court said that, whether this is a proper construction of the ordinance, and whether, thus construed, it is unconstitutional, were questions not necessary to a decision of the case. It was not shown that the plaintiffs had been prevented from making such use of the garbage. King complained because his right to sell garbage had been invaded, and the petition did not show that he did, or desired to, feed the garbage to fowls or animals on his premises. Urbach complained because the ordinance denied him the right to purchase and remove garbage produced on the premises of others.

Under a statute giving a city power to make regulations to secure the general health, to prevent and remove nuisances, and to compel and regulate the removal of garbage beyond the corporate limits, the Kansas Supreme Court holds, O'Neil *v.* Harrison (Kans., 1915), 150 Pac., 551, that the city may grant an exclusive right to the highest bidder to remove all garbage; the term being defined, in the ordinance authorizing the action, to mean "all rejected food and offal." The court said that it did not regard the mere fact that the city would derive some revenue from the measure as taking it out of the category of police regulations.

The regulations promulgated by the Commissioners of the District of Columbia for the collection and disposal of garbage, under the act of Congress of June 6, 1900, provide, as required by the act, for a disposition of all garbage by a reduction and consumption process, and in addition prohibit the removal and disposition of garbage by anyone other than the garbage contractor, and also probibit the transportation of garbage beyond the District for the purpose of feeding it to animals. In sustaining these regulations as a valid exercise of the police power, the Court of Appeals for the District of Columbia holds, Dupont *v.* District (1902), 20 App. (D. C.), 477, that, although all matter which may be laid aside merely in the preparation of dishes for the table is not necessarily garbage, and, therefore, subject to the same regulation in all respects, still, when such matter is mingled with garbage it becomes likewise subject to public control, notwithstanding that in some instances the owners might be able to dispose of it for a price to persons willing to make use of it in its unreduced state as either animal food or fertilizer.

In City of Rochester *v.* Gutberlett (1914), 211 N. Y., 309, the New York Court of Appeals held that it is within the power of the municipality not only to impose reasonable restrictions and regulations upon the manner of removing garbage, but also, if it sees fit, to assume exclusive control of the subject, and to provide that garbage and refuse matter shall only be removed by the officers of the municipality or by a contractor hired by the municipality, or by some single individual to whom an exclusive license is granted for that purpose. An exclusive right so created is not open to the objection that it is a monopoly. This was an action to enjoin an ordinance regulating the gathering of garbage, letting the contract therefor, and cancelling all permits theretofore issued, at the instance of a farmer who, along with others, had collected garbage under licenses from the city. The court said that experience has shown that when there are many collectors of garbage within a municipality, acting independently although under license, it is difficult to maintain the supervision necessary to preserve the public health; while, with one contractor acting under a contract pursuant to which he is paid and for the faithful performance of which he is required to give bond with sureties, the public health can be and is better and more surely protected. In this particular case there was nothing in the ordinance to prevent the owner of a restaurant or hotel from removing the garbage bones and kitchen refuse on his own property to a place where it would not be a nuisance to the public health, there to be fed to hogs or otherwise disposed of in such a manner as to such owner might seem desirable.

A similar case to the above was State *v.* Orr (1896), 68 Conn., 101, when the court said that such an ordinance is not invalid as to one whom a license or permit has been refused. The fact that all garbage collected by him comes from certain restaurants, with the proprietors of which he has contracts for its removal, does not render the ordinance invalid as an interference with his contracts when it does not appear that the contracts were entered into before the adoption of the ordinance. Nor does the fact that the garbage collected by him is fresh, and some of it fit for food, render the enforcement of the ordinance, as to him, a deprivation of property without due process of law.

Similar ordinances have been sustained in the following cases: California Reduction Co. *v.* Sanitary Reduction Works (1905), 199 U. S., 306, affirming 126 Fed., 29; Gardner *v.* Michigan (1905), 199 U. S., 325; Walker *v.* Jameson (1894), 140 Ind., 591; State *v.* Payssan (1895), 47 La. Ann., 1029; Ouray *v.* Corson (1900), 14 Colo. App., 345; Re Vandine (1826), 6 Pick (Mass.), 187; Grand Rapids *v.* De Vries (1900), 123 Mich., 570; Iler *v.* Ross (1902), 64 Nebr., 710; State *v.* Robb (1905), 100 Me., 180; Ex parte London (Tex. 1914), 163 S. W., 968; Ex parte Howell (Tex. 1913), 158 S. W., 535; Atlantic City *v.* Abbott (1906), 73 N. J. L., 281; Coombs *v.* MacDonald (1895), 43 Nebr., 632; Smiley *v.* MacDonald (1895), 42 Nebr., 5.

But in Knauer *v.* Louisville (1898), 20 Ky. L. Rep., 193, 45 S. W., 510, an ordinance of this kind was held unreasonable and confiscatory.

Although an early case in Pennsylvania, Kussel *v.* City of Erie (1898), 8 Pa. Dist., 105, held that an ordinance prohibiting, under penalties, persons who had not contracted with the city for removing garbage, was invalid because in restraint of trade, and because it deprived citizens of their property without due process of law; later Pennsylvania cases hold that cities authorized by statute to make regulations to secure the general health and to remove and prevent nuisances may by ordinance provide for contracts for the exclusive right to remove garbage and prohibit others from doing so under penalty. Butler Borough *v.* Logan (1910), 19 Pa. Dist., 952; Harrisburg *v.* Martin (1909), 20 Pa. Dist., 325; Marple *v.* Pfanner (1911), 21 Pa. Dist., 851.

In Smith *v.* City of Spokane (1909), 55 Wash., 219, it was held that a city ordinance which created a crematory department, and made it unlawful for any persons other than employees of that department to convey garbage through the city streets, is a lawful exercise of the police power in the interest of the public health, though it destroys business of persons who had previously been engaged in hauling garbage. To the same effect are the cases of Schultz *v.* State (1910), 112 Md., 211; 76 Atl., 592; Nash *v.* District of Columbia (1907), 28 App. Cas. (D. C), 598; Atlantic City *v.* Abbott (1906), 73 N. J. L., 281, 62 Atl., 999; Board of Health *v.* Vink (Mich., 1915), 151 N. W., 672; Ex parte London (1914), 73 Tex. Crim., 208.

The California Supreme Court holds, Ex parte Zhizhuzza (1905), 147 Calif., 328, that a city with charter power to regulate business that may endanger the public safety, health, and comfort had power to pass an ordinance providing that the city should have the exclusive right to remove garbage, and imposing a small fee for its removal, recoverable by civil action.

Ohio has a statute (Gen. Code, sec. 3649), authorizing municipalities to provide by ordinance for the collection and disposition of sewage, garbage, dead animals, etc., and to maintain and regulate plants for the disposal thereof. It has been held that under this section a municipal corporation may grant a monopoly for removing and making use of the dead bodies of animals which have not been slaughtered for food. (Stadler *v.* Cleveland, 4 O. N. P. (U. S.), 649; 17 O. D. (N. P.) 340.) On the other hand, it has been held that an ordinance which forbids the transportation of any dead animals, fish, or garbage, including condemned human food, through the streets of a municipal corporation by any person except the city contractor or his agent, is invalid, as in violation of the Fourteenth amendment of the Constitution of the United States. (Bauer *v.* Casey, O. C. C. (U. S.), 69, 16 O. C. D., 598.)

Illinois has a statute providing that any city having a population of more than 100,000 may make contracts for more than one year and not exceeding five years, relating to the collection and final disposition of garbage and ashes. (Hurd's St. Ch., 24, sec. 623.)

APPENDIX II.—REFUSE DISPOSAL BIBLIOGRAPHY.[1]

The titles of magazines, with the place of publication and the abbreviations used in the bibliography, are as follows:

Name of magazine.	Abbreviations.	Place of publication.
The American City	Am. City	New York City.
Association of Engineering Societies	Assoc. of Eng. Soc	Philadelphia, Pa.
Canadian Engineer	Canadian Eng	Toronto, Ontario.
The Contract Record	Cont. Rec	Do.
Engineering News	Eng. News	New York City.
Engineering Record	Eng. Rec	Do.
Engineering News-Record	Eng. News-Rec	Do.
Engineering and Contracting	Eng. & Cont	Chicago, Ill.
The Gas Age	Gas Age	New York City.
Manufacturers Record	Man. Rec	Baltimore, Md.
The Modern City	Modern City	Do.
Municipal and County Engineering	Mun. & County Eng	Indianapolis, Ind.
Municipal Engineering	Mun. Eng	Do.
Municipal Engineering and Sanitary Record.	Mun. Eng. & San. Rec	London, England.
Municipal Journal	Mun. Jour	New York City.
Municipal Journal and Public Works	Mun. Jour. & Pub. Works	Do.
The Municipal World	Mun. World	St. Thomas, Ontario.
Pacific Municipalities		San Francisco, Calif.
Public Works		New York City.
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